Farm Saved Seed (FSS) and Royalty Generation for Wheat in France, United Kingdom, and Australia – Policy Implications for Canada

A Thesis Submitted to the College of
Graduate Studies and Research
In Partial Fulfillment of the Requirements
For the Degree of Master of Science

In the Department of Bioresource Policy Business and Economics (BPBE)
University of Saskatchewan
Saskatoon, Canada

By
Seraina M. Giovanoli

Permission to Use

In presenting this thesis in partial fulfillment of the requirements for a postgraduate degree from the University of Saskatchewan, I agree that the libraries of this University may make it freely available for inspection. I further agree that permission for copying this thesis in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and the University of Saskatchewan for any scholarly use which may be made of any material in my thesis.

Requests for permission to copy or to make use of material in this thesis in whole or in part should be addressed to:

Head of Department of Bioresource Policy, Business and Economics (BPBE)

University of Saskatchewan

Saskatoon, Saskatchewan

S7N 5A8

Abstract

The majority of wheat research in the world and in Canada is conducted by the public sector. The government of Canada has introduced legislation to update its plant breeder's rights (PBR) legislation, making Canada compliant with the International Union for the Protection of New Varieties of Plants (UPOV) 91 convention, with the goal to stimulate private investment in wheat variety research. International experience with UPOV 91 reveals a wide range of outcomes depending on the specific royalty setting mechanisms allowed within their domestic legislation.

This thesis compares Canada's existing policy to three very different international examples (France, United Kingdom, and Australia) of UPOV 91 compliant royalty collection systems for wheat. The model presented is one of a monopolistic competitive wheat-breeding industry with the introduction of a new certified seed variety. Farmers have the option to use farm saved seed (FSS) or certified seed on their farm. The additional economic benefit created from the innovation and its distribution is analyzed and interpreted for both, farmers (social benefit) and breeders (private benefit).

The results of the analysis show that while each UPOV 91 compliant model generates more revenue for farmers and breeders than Canada's current policy, they tend to generate less than expected revenue in the short-run. If a country has strong intellectual property rights (IPRs), it will attract some domestic and foreign investment and possibly a beneficial collaboration between the public, private, and producer sector, also known as P4 (public-private-producer-partnerships).

Key words: UPOV, TRIPS, Intellectual Property (IP), monopolistic competition, public and private research, wheat research, farm saved seed (FSS), welfare analysis, Australia, France, United Kingdom, Canada.

Acknowledgements

I would like to express my special appreciation and thanks to my advisor Professor Dr. Richard Gray, you have been a tremendous mentor to me. I would like to thank you for encouraging my research and for allowing me to grow as a research scientist. Your advice on both research as well as on my career have been priceless. I would like to thank you for your exceptional guidance, caring, patience, and providing me with an excellent atmosphere for doing research. Without your supervision and constant help this thesis would not have been possible.

I would also like to thank my committee members, professor Joel Bruneau and professor Murray Fulton for serving as my committee members, and Wayne Thompson for serving as my external advisor. I would like to thank you for your brilliant comments and suggestions and for letting my defense be an enjoyable moment.

I would also like to thank other professors for their support during my M.Sc. thesis and the Alliance for Food and Bioproducts Innovation (AFBI) for their generous scholarship to support this thesis.

A special thanks to my family; words cannot express how grateful I am to my parents for all of the sacrifices that you have made on my behalf and their support throughout my personal and academic life. Thank you for your support and encouragement to strive towards my goals.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

AAFC	Agriculture and Agri-Food Canada
AGPB	Association Générale des Producteurs de Blé
AGT	Australian Grain Technologies Pty. Ltd.
ANR	Agence Nationale Recherche
AUD	Australian Dollar
AWCPA	Australian Winter Cereals Pre-breeding Alliance
BSPB	British Society of Plant Breeders
CAP	Common Agricultural Policy
CIMMYT	(English Translation) International Maize and Wheat Improvement Centre
CFIA	Canadian Food Inspection Agency
CGIAR	Consultative Group on International Agricultural Research
CPVO	Community Plant Variety Office
CPVR	Community Plant Variety Right
CSTA	Canadian Seed Trade Association
CTPS	Technical Committee for Plant Breeding
CVO	Contribution Volontaire Obligatoire
CWAD	Canada Western Amber Durum (wheat)
CWRS	Canada Western Red Spring (wheat)
DUS	Distinctness Uniformity and Stability (pertaining to a plant variety)
EDV	Essentially Derived Variety
EPC	European Patent Convention
EPR	End Point Royalty
EPVR	European Plant Variety Rights
ESA	European Seed Association
ESC	Eastern Standards Committee
EU	European Union
FAO	Food and Agriculture Association
FAS	Foreign Agricultural Service
FSOV	Fonds de Soutien a l'Obtention Végétale en blé tendre
FSS	Farm Saved Seed
GM	Genetically Modified
GNIS	Groupement National Interprofessionnel des Semences et plants
GRDC	Grains Research and Development Corporation
GURT	Genetic Use Restriction Technology
HGCA	Home Grown Cereal Authority
INRA	The Institut National de la Recherche Agronomique
IP	Intellectual Property
IPR	Intellectual Property Rights
ISF	International Seed Federation
ISTA	International Seed Trade Association
MP	Marginal Product
MT	Megaton
MTA	Material Transfer Agreement
NABIM	National Association of British and Irish Millers

NFU	National Farmers Union
OECD	Organization for Economic Co-operation and Development
PPPP (P4)	Public Private Producer Partnership
BI	Plant Breeders' Institute
PBR	Plant Breeders' Rights
PBRA	Plant Breeders' Rights Act
PCT	Patent Co-operation Treaty
PVRA	Plant Variety Rights Act
PVP	Plant Variety Protection
RA	Regulatory Authority
R&D	Research and Development
RDC	Research and Development Corporation
PRRCG	Prairie Registration Recommending Commending Committee for Grain
SICASOV	Société Coopérative d'Intérêt Agricole des Sélectionneurs Obtenteurs de Variétés Végétales
SNICS	Servicio Nacional de Inspección y Certificación de Semillas
SOC	Service Officiel de Contrôle et de Certification
STV	Saatgut-Treuhand-Verwaltung GmbH
TRIPS	Agreement on Trade Related Aspects of Intellectual Property
UPOV	Union for the Protection of New Varieties of Plants
UK	United Kingdom
US	United States
USD	US Dollar
VCU	Value for Cultivation and Use
VMP	Value Marginal Product
VRO	Variety Registration Office
WGRF	Western Grains Research Foundation
WIPO	World Intellectual Property Organization
WTO	World Trade Organization
WTP	Willingness to Pay

1 General Introduction

Plant breeding is the single most important tool that delivers solutions to the challenges of food security, climate change and the more efficient use of resources as well as making a major contribution to economic growth (Alston et al., 1995). Plant breeding and research are essential to maintain pest resistance and to increase productivity at the farm level. However, breeding new crop varieties is a lengthy process requiring several years of substantial investment. Public breeding institutions generally have limited funding available for projects and have to allocate their resources accordingly. Private breeding companies only invest where they see a potential for profits or where they know they can at least recover their high investment costs. According to Alfranca (2005) profitability depends on a country's contract enforcement regulations or patent property right protection. As an incentive to attract private investment to a country, newly developed plant varieties need to be protected through intellectual property rights (IPRs) if technical intellectual property (IP) protection is not possible (Lence and Hayes, 2008).

Bill C-18 – A General Overview

Currently Canada is a signatory of the International Union for the Protection of New Varieties of Plants, known as UPOV, which was created in 1961 and updated in 1978 and again 1991 to strengthen IPRs. An in-depth review of UPOV 78 and 91 is conducted in chapter 2. Today, most countries that are part of UPOV are signatories of UPOV 91. Canada signed UPOV 91 in 1994 but has never passed UPOV 91 consistent legislation. In December 2013, the government of Canada introduced Bill C-18, also known as "The Agricultural Growth Act". "Bill C-18 is designed to modernize and strengthen federal agriculture legislation, support innovation in the Canadian agriculture industry and enhance global market opportunities" (CFIA, 2013).

The main purpose for the revisions to the Plant Breeders Right (PBR) Act included in the Bill is to (1) encourage investment in plant breeding in Canada, (2) attract foreign varieties to Canada, (3) align the current statute with the UPOV 91 convention, and (4) allow farmers access to the best varieties available in any country that is party to UPOV 91. The Bill is particularly important for crops without technical IP protection or patent protection.

This thesis focuses on the implications of UPOV 91 protection for wheat, which is the largest crop in Canada without technical IP or patent protection.

1.1 Background

To better understand the importance of the Bill for the future of Canada's wheat-breeding, it is important to understand Canada's position on the global wheat market, who the major producers are, Canada's current policy standing, and the importance of private investment in the country.

World Wheat Market

As of 2011, wheat was the largest food crop produced in the world and the most traded (FAOSTAT, 2011). As such, it plays an essential role in global food security. Today, most production increases are due to improved yield varieties, pesticides, fertilizers and the use of irrigation (University of Saskatchewan, 2012). Yield gains in many countries have, however, been leveling off during the past 25 years (Knight et al., 2012). Figure 1.1 shows the top 10 wheat producing countries in the world in 2013:

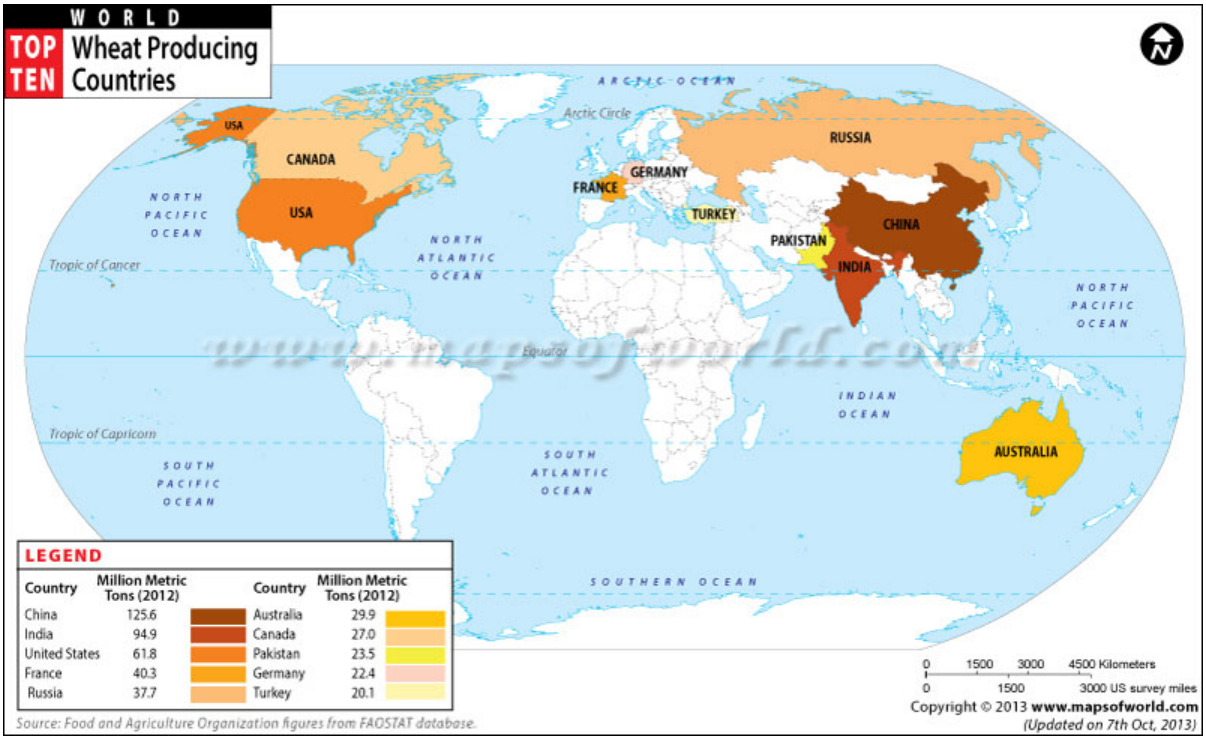

Figure 1.1: Top Ten Wheat Producing Countries in the World

Source: Food and Agriculture Organization FAOSTAT, 2013.

With about four percent of global production, Canada is one of the top ten wheat-producing countries in the world and is one of the largest exporters of wheat. As the largest crop grown in Canada, wheat remains important for the regional and national economy. More information on Canada's wheat industry is given in chapter 7. The intensity of investment in wheat breeding and research has fallen behind corn, soybean, and canola, where hybrid and patent protection has attracted significant private breeding investment. As a non-hybrid and a non-genetically modified (GM) crop, wheat reproduction can only be protected with IP protection, such as stronger plant breeders' rights (PBRs), which in Canada are lacking. Because proper IP protection is not available, private companies have limited ability recover investment costs, nor make a profit in the long run, which suggests the lack of private investment for wheat in Canada.

1.2 Problem Statement

Wheat is the dominant grain of world commerce, is easily transported and stored (University of Saskatchewan, 2012). In 2011, 33 percent of the total crop area planted in Canada was wheat, making it the largest crop grown in the country. Canada is a world leader in the development, production and marketing of canola and other pulses, but is falling behind in wheat (ISF, 2011). Canada's share of world wheat market is shrinking. One of the main reasons may be due to an underinvestment in wheat research (Gray and Veeman, 2009), and that may be due to the lack of plant variety protection (PVP) mechanism in place. Most new wheat varieties developed originate from the public sector, which is funded by the federal and provincial governments and through the Western Grains Research Foundation (WGRF), which is funded by producer levies. WGRF funds mainly projects with focus on yield increases and disease resistance, and other agronomic issues (AAFC, 2012). The Alberta Crop Industry Development Fund (ACIDF), and the Saskatchewan Agricultural Development Fund (ADF) also fund a significant amount of agronomic research (ACIDF, 2014; ADF, 2014). In this thesis the annual benefit distribution in each country considers only royalty investment, without the levy- and public investments.

In Canada, only about two percent of wheat breeding and research is conducted by the private sector (ISF, 2011). The private sector is willing to invest in research if there is potential to recover research costs and make a profit. In North America, private investment is significant in crops where IP is protected through utility patents and hybrid technologies (Alston et. al., 2012). The right to exclude others from using a new technology is very important to promote

private investment (Gray, 2011). The majority of countries part of the Organization for Economic Co-operation and Development (OECD) passed UPOV 91 convention, except for Canada and eight other countries. Australia, EU, Russia, United States (US), and the Ukraine, Canada's major wheat export competitors, are all part of UPOV 91 (Wood, 2013).

It is also worth noting that moving toward stronger IPRs is not without some controversy. International corporations dominate the applications for PBRs and patents in developing countries. These corporations hold 97 percent of all patents and 90 percent of all technology and product patents. The large percentage of patent and product holdings provides them with a lot of power and control over the seed industry (Kuyek, 2001).

Market Failure

The reproduction of wheat occurs through open pollination. Once farmers plant a new seed variety with the improved technology, wheat reproduces and the farmer can save the seed. In the absence of legal restrictions, farmers can benefit from the new genetics for years following the original purchase for free. The ability to reproduce a variety for free poses an issue for private companies that want to create a new wheat variety because the knowledge is embodied within the seed. A new variety is "non-excludable", meaning that once a farmer sows the seed and harvests it, the farmer can use the knowledge in the future without paying for it. Non-excludability leads to spillovers, where farmers receive a large portion of the benefit, while decreasing the breeders' benefit (Alston et al. 2012). When private breeders cannot appropriate sufficient returns from their investment, it reduces the private incentive to invest money in breeding, which leads to market failure. IPRs can address the issue of excludability and market failures related to spillovers, which is the case in Australia, further discussed in chapter 6. Seed is also "non-rival", such that if one farmer uses the variety, it does not exclude another farmer from using it as well. Non-rivalry creates economies of size, which can lead to market power issues in industries with strong property rights.

This thesis does not conduct a social welfare analysis. It addresses the issue of underinvestment of private wheat-breeding firms. Public investment is excluded from this analysis.

As Canada contemplates how to design a system to implement UPOV 91 PBRs, international experience can provide valuable insights. Other countries, notably France, United Kingdom (UK), and Australia have used UPOV 91 PBRs to strengthen property rights and create a royalty stream to support additional research.

This begs the questions of: (1) To what extent has the introduction of UPOV 91 PBRs affected the economic transfer of surpluses from breeders to farmers due to incomplete property rights and private investment incentives in these countries? (2) Which system is most efficient, considering farmer and breeder benefit distributions, in royalty generation and wheat breeding? (3) And, what can Canada learn from international experience?

1.3 Objectives

As Canada moves forward with the introduction of UPOV 91, I analyze the royalty collection systems of France, UK, and Australia, which are compliant with UPOV 91 but have implemented PBRs in different ways. These three systems are very different from each other and seem to be the three main options available for Canada moving forward. In this thesis, I examine the ability of these systems to create private incentives for research, discuss the strengths and the weaknesses of each, and identify what Canada could learn or adapt to from such a system.

The specific objectives of this thesis are to:

(1) Develop a greater understanding about the **competitiveness** of the wheat-breeding industry. How is the pricing of certified seed impacted by the existence of farm saved seed (FSS)?

(2) Identify the incentives created by **intellectual property rights (IPRs)**. Given the current royalty rates for FSS and certified seed within each country, calculate the benefit that breeders (private benefit) and farmers (social benefit) receive, which they are not paying for. This will address the question of: Of the total economic benefit created, do breeders get a large enough share of the benefit through the royalties to have enough incentive to keep researching and investing in the wheat-breeding industry?

(3) Identify which of these three systems would best be adapted for Canada.

1.4 Methodology

Two methods are used to analyze how the countries collect royalties and how the parties (breeders and farmers) are benefitting from the current royalty rates charged.

First, I apply a six panel monopolistically competitive model to the wheat-breeding industry. This model aids in understanding how the FSS royalty impacts on what breeders charge for the certified seed royalty in each country.

Secondly, I calculate the additional annual benefits for farmers and breeders created by the introduction of a new wheat variety. Given the current royalty rates, I calculate the transfer of surplus from breeders to farmers from the introduction of the new variety due to incomplete property rights. Calculating this surplus transfer provides an indication of the ability to address market failure and create optimal private incentives for research through royalty rates.

1.4.1 Expected Results

I expect the results gained for France, UK, and Australia show that UPOV 91 has created incentives for private breeding. Given that each country has some private breeding activity, each system is able to generate private surplus for the breeders. Given the strength of the Australian IP system managed through end point royalties (EPRs), this system may allow the breeders to capture a larger share of benefits as compared to other countries. If breeders can capture more of the benefit created from their own innovation through royalties, they will likely remain in the country to conduct future research and variety enhancement.

1.5 Organization of Thesis

In this thesis, I analyze the incentives created by IPRs and the funding mechanisms for wheat breeding in France, UK, and Australia and from this analysis I draw some possible implications for the public and private wheat breeding institutions in Canada after the adoption of UOPV 91. The analysis includes looking at royalty collection mechanisms in other countries and other funding methods for research and development (R&D) focused on wheat. I discuss the proposed IPRs outlined in UPOV 91 and explain how they have affected wheat research in other countries. I also analyze the additional annual benefits created for farmers and breeders through

wheat breeding and varietal improvement. Lessons and options for Canada's future policy and practice are outlined.

In chapter 2 I briefly describe the background of legal plant protection, including UPOV, the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) and other mechanisms used by different governments. In chapter 3 I outline the theoretical framework for the thesis. In chapter 4 I describe the French wheat royalty system, institutions involved in breeding and royalty collection, as well as the additional annual benefits created for farmers and breeders found in the country. In Chapters 5 and 6, I describe the UK system and the Australian system respectively in the same way as done for France. In chapter 7 I briefly describe the current situation for the wheat-breeding industry in Canada. In chapter 8 I summarize and conclude the thesis and its findings. Lessons for the Canadian future wheat industry are outlined in section 8.1.

2 Background – Methods of Plant Protection

Legal intellectual property rights (IPRs) and technical intellectual property (IP) protection mechanisms, such as hybrids, can exclude others from reproducing a new crop variety. These mechanisms allow the owners and breeders of a new variety to charge for their innovation. As such, for the crops that lack technical IP protection, the introduction of IPRs is necessary for the development of a private crop research industry. Most crops that are open pollinated can be reproduced at a low cost by saving and using seed from the previous harvest. The practice of saving seed is very common and is often referred to as farm saved seed (FSS). In the absence of adequate IPRs and in the presence of FSS, breeders often cannot recover their investment costs. It is important to note that the new technology needs to create benefits for farmers (lowering of prices) as well as for breeders (increase in supply) so that breeders keep innovating and farmers keep adopting new varieties. But as benefits transfer from breeders to farmers to a point where breeders do not receive enough remuneration, private breeders will stop innovation in a given country.

Some countries have stronger IPRs than others, depending on the regulations implemented. Stronger IPRs enhance the ability to capture value, increasing the possibility of profits, therefore, private plant breeders will tend to locate and invest in those countries. Since most countries and intergovernmental organizations that offer a plant variety protection (PVP) system for open pollenated crops have chosen to base it on the International Union for the Protection of New Varieties of Plants (UPOV) convention, I mainly focus on UPOV throughout this thesis.

2.1 Introduction

In this chapter, I describe the various international legal regimes governing IPRs in plant varieties. I structure the protection methods in four major sections; legal, contractual, technical, and social, and present them in the following way:

Some countries use a legal (publically based) framework to protect the seed innovations created in their countries. The legal options include the UPOV convention, the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), patents, 1994 EU legislation, and utility patents. If a legal framework is not available, some breeders create a contractual (farmer-breeder based) framework. The contractual framework includes contracts, bag labels, and

technology use agreements (TUA). Another option to the contractual framework is a technical (private based) framework. The varieties are protected using a technical mechanism. Methods included in this group are hybrids and Genetic Use Restriction Technologies (GURTS). The last method of protection is trade secrets, one based on a social mechanism. Some of these methods mentioned can only be enforced if countries are part of TRIPS or UPOV, both which are discussed below.

2.2 Legal (Public) Protection

The legal framework includes the two large intergovernmental organizations such as the International Union for the Protection of New Varieties of Plants (UPOV) and the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), in addition to patents and utility patents. Plant variety protection (PVP) is the standard method of protecting innovative plant varieties in many countries. The UPOV provides the legal framework for the plant breeders' rights (PBRs) in most countries. Member countries agree to the rules and regulations when they sign the convention (ISF, 2011). In addition to the UPOV, if the countries are also members of the World Trade Organization (WTO) they have to comply with TRIPS (UPOV, 2012). Unlike patents, PBRs are automatically enforced in every country that is member of UPOV.

2.2.1 International Union for the Protection of New Varieties of Plants (UPOV)

The UPOV is an intergovernmental organization in which all countries have the opportunity to join. However, once a member of the organization, a country becomes bound to the UPOV convention that passed legislation. "The mission of the UPOV is to provide and promote an effective system of plant variety protection, with the aim of encouraging the development of new varieties of plants, for the benefit of society" (UPOV, 2014).

The UPOV convention was drafted in 1961, revised in 1972, 1978 and 1991. The convention was set up to provide protection for plant breeders in their own and overseas markets. Figure 2.1 shows current UPOV member countries (green), countries that have initiated the procedure for acceding to the UPOV convention (brown), and countries in contact with UPOV for assistance in the development of laws based on the UPOV convention (orange). As of 2014, 72 countries in total were parties of UPOV, 19 to the 1978 convention, 52 to the 1991 convention and one to the 1961 convention (UPOV, 2014).

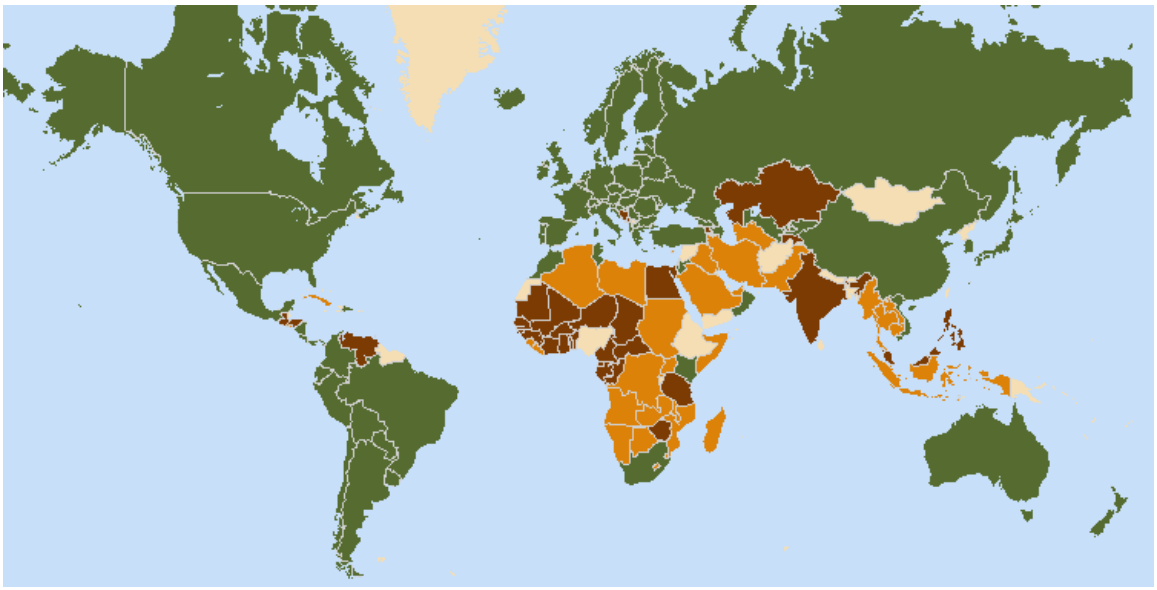

Figure 2.1: Members and Potential Future Members of UPOV

Source: UPOV, 2014.

The UPOV convention requires member countries to provide intellectual property rights (IPRs) specifically for plant varieties. The UPOV convention adopts a *sui generis* (adj. Latin for "one of a kind" or "unique") system of protection especially tailored to the needs of plant breeders. This form of IPR is referred to as plant breeders' right (PBR) (Nottenburg, 2012). Breeders in most countries use PBRs to protect their varieties as in most countries a plant variety *per se* (adj. Latin for "by itself") is not patentable, but a trait within a variety may be patented (BSPB, 2011). As described in the UPOV convention, to qualify for a grant of PBR, a variety must be morphologically distinct, uniform and stable (DUS). "To satisfy the requirement of *distinctness*, a variety must be clearly distinguishable from any other variety whose existence is a matter of common knowledge" (UPOV, 2002 p. 13). According to Article 6 of the UPOV 1961 and 1978 conventions, "a variety is deemed *uniform* if it is sufficiently homogeneous, having regard to the particular features of its sexual reproduction or vegetative propagation" (UPOV, 2002 p. 13).

Article 8 of the UPOV91 convention "deems that a variety is *uniform* if, subject to the variation that may be expected from the particular features of its propagation, it is sufficiently uniform in its relevant characteristics" (UPOV, 2002, p. 19). In the UPOV 1961 and 1978 conventions, a variety "must be *stable* in its essential characteristics, that is to say, it must remain

true to its description after repeated reproduction or propagation or, where the breeder has defined a particular cycle of reproduction or multiplication, at the end of each cycle" (UPOV, 2002 p. 20). Similar in the UPOV 91 convention, "a variety shall be deemed to be *stable* if its relevant characteristics remain unchanged after repeated propagation, or in the case of a particular cycle of propagation, at the end of each cycle" (UPOV, 2002, p. 23). New in the UPOV 91 convention, a variety must also show "*novelty*" which is described in Article 6 as "the variety shall be deemed to be new, if at the date of filing of the application for a breeder's right, propagating or harvested material of the variety has not been sold or otherwise disposed of to others, by or with the consent of the breeder, for purposes of exploitation of the variety" (UPOV, 2009, p. 4).

Countries either have an "automatic incorporation" of the UPOV convention or a "legislative incorporation". The first just needs to implement legislation to authorize administrative agencies to process applications. In the latter, UPOV does not become enforceable by law until the country enacts a national plant variety protection (PVP) law that conforms to the convention's requirements (Helfer, 2011, p. 21). Canada has a legislative incorporation and currently uses UPOV 78, but is in the process and could pass legislation for UPOV 91 (see: Bill C-18) as early as August 2014.

2.2.1.1 UPOV 1978

Plant breeders' rights (PBRs) under UPOV 78 are less restrictive than under UPOV 91. Under the UPOV 78 convention, not all plant varieties need to be protected. The countries are obligated to protect five varieties on the date the convention enters into force and add at least another 19 within eight years. The convention also permits protection of plant varieties by either PBR or patents but not both (Helfer, 2011, p. 22). The convention does not require protection of harvested material. However, one needs to obtain permission from the breeder for production, sale or commercial marketing of the seed for the protected variety. The minimum term of protection is 15 years for wheat (Helfer, 2011, p. 23). The 1978 convention contains the breeders' rights and the farmers' privilege, which are explained in more detail below.

2.2.1.2 UPOV 91

UPOV 91 poses stricter requirements as opposed to UPOV 78. The UPOV 91 convention requires member states to protect at least 15 plant species upon the signing of the convention and to extend protection to all plant varieties within ten years (Helfer, 2011, p. 26). The convention also contains a definition of "variety" as compared to UPOV 78 and also permits member states to protect the same plant variety with both PBRs and patents. Exclusive rights of UPOV 91 extend not only to propagating material, but also to any harvested material that is grown from the unauthorized use of the propagating material. UPOV 91 extends the term of protection for wheat from 15 to 20 years (Helfer, 2011, p. 28). The breeders' rights and farmers' privilege are also contained in this convention (Helfer, 2011, p. 29).

Farmers' Privilege (Agricultural Exemption)

An optional clause called farmers' privilege is included in the UPOV convention, which grants farmers the right to save their harvest to use for propagating purposes on their farm without the breeders' prior authorization (Art. 23). New in UPOV 91, the farmer, with the exception of small farmers, may have to pay the holder an equitable remuneration (Art. 23.1, 3) for the use of the protected variety. Farmers are, however, not allowed to sell the seed to third parties. The farmers' privilege is also known under the term of "farm saved seed" (FSS). FSS can lead to issues and challenges within the system pertaining to the collection of royalties for breeders (ISF, 2011). Some nations only permit farmers to plant FSS to be used on their own land holdings, while others allow them not only to replant but also to sell limited quantities of seed for reproductive purposes, a practice often referred to as "brown bagging". The convention also allows restricting breeders' rights so that breeders must receive remuneration (Helfer, 2011, p. 23). This means that if a farmer purchases seed from a breeder, the breeder can make the farmer enter a license agreement that authorizes the farmer to reproduce seed only if they agree to pay a royalty on all products from the variety. In Australia, for example, the breeders have a claim for harvested material created from unauthorized use that enables the enforcement of bag licenses.

Breeders' Rights

The breeders' rights is a mandatory clause and gives "breeders of protected varieties the right to authorize or refrain from authorizing other breeders seeking to use the protected variety to create new varieties or to market those varieties" (Helfer, p. 23, 2011). In addition, the following acts in respect of the propagating material of the protected variety shall require the authorization of the breeder for production or reproduction; conditioning for the purpose of propagation; offering for sale; selling or marketing; exporting; importing; and stocking for any of the purposes mentioned (UPOV, 2010). Some countries have introduced a "breeders' exemption" allowing breeders to use the patented trait for research without the original breeders' permission. However, new varieties cannot contain the previously patented trait unless the patent holder grants a license to do so (ISF, 2011).

The breeders' rights in the UPOV 91 convention are expanded to the following restrictions: (1) production and reproduction for propagation, exporting, importing, and stocking of propagating material of a variety, (2) rights extend to essentially derived varieties (EDV) which are predominantly derived from the protected variety (retains all essential characteristics except differences arising from derivation), (3) rights extend to harvested materials obtained through unauthorized use of propagating material, where the breeder had no reasonable opportunity to exercise rights, (4) duration of the protection is expanded from 15 to 20 years for wheat, (5) currently, no prior sales are allowed in Canada before applying for PBR protection, however, with the new convention, sales are allowed up to one year prior to application, (6) applicants receive an automatic provisional protection from the date the application was accepted for filing.

The breeders' rights have the following restrictions:

(1)Breeders' exemption (compulsory): No authorization required to breed from a PBR protected variety.

(2)Research exemption (compulsory): No authorization required to conduct research and experimentation on a PBR protected variety.

(3)Private exemption (compulsory): No authorization required for private/non-commercial acts (e.g. gardeners) (Parker, p. 34, 2014).

2.2.1.3 Proposed UPOV 91 Amendments to Canada's PBR Act (Bill C-18)

To understand the arguments made in this thesis, it is important to understand the major proposed changes to the underlying amendments (Parker, 2014). The purpose of the Agricultural Growth Act (Bill C-18) is to bring Canada in conformity with UPOV 91.

Table 2.1 shows the major changes occurring with the adoption of UPOV 91.

Table 2.1: Changes Occurring by Updating to UPOV 91

UPOV 78 **Canada's Legislation Complies**	**UPOV 91** **Canada's Legislation Does Not Comply**
Article 4 – Eligibility Criteria	
Sales of the new variety are allowed once the IPR has been approved	Allows sales up to a year prior to the IPR approval
Article 5 – Scope of the Breeders' Right – Stronger Protection	

• Needs breeders prior authorization for:
  • Production for commercial marketing
  • Offering for sale
  • Marketing
Of the reproductive material
• Material can be used in research trials
	• Expands to purposes of propagation, importing, stocking and exporting
	• Extends the right to harvested material, if the breeder has not had the opportunity to exercise his right (e.g. royalty)
	• Extends to Essentially Derived Varieties (EDV)[1]

Article 5.1 - Liability	
In an unauthorized sale, only the seller is liable for breach of contract	If an infringement occurs, both parties (seller and buyer) are liable.
Article 5.3 – Restriction to Breeders' Rights and Farmers Privilege	
Canada does not prevent the use of protected material to develop new varieties	New, the breeders exemption, research exemption, and private exemption are all compulsory, which strengthen breeders rights
There is no provision for an exception to the right to allow the farmer to save the harvested material from a protected variety	Includes an optional clause to allow farmers to save and use FSS on their own farms.
Article 6 – Duration for Protection	
Protection is 18 years for all species in Canada	Extends minimum protection period to 20 years for most species; 25 years for vines, fruits and trees.

Source: Parker 2014; UPOV, 2010.

[1] EDV - Where it can be proven that a new variety has been derived from an initial variety that is

While the Bill has a clear provision for FSS, the amendments to Articles 5 and 5.1 make it far easier for a breeder to enforce any bag license which they can use upon the sale of seed to oblige the farmer to pay a royalty on the use of FSS or on the sale of their product in the form of an end point royalty (EPR).

2.2.1.4 1994 EU legislation

Most European countries are part of the UPOV convention to protect their plant varieties. To harmonize the countries and to facilitate IP protection within the EU, the Community Plant Variety Right (CPVR) *acquis* (adj. French for "that which was agreed upon" or "of the community") was created in 1994 based on the UPOV 91 principles (Jolly, 2012). CPVR allows IP protection for the breeder throughout the whole territory of the EU via one title through one application. A holder of a variety protected through UPOV can extend the protection and apply for a CPVR protection within the EU. To be granted CPVR the variety has to fulfill the DUS requirements according to Article 10 of the basic UPOV convention. One percent of all EPVR applications originate from non-EU applicants (CPVO, 2013).

2.2.2 Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS)

The Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) was a part of a global package deal, which was administered by the World Trade Organization (WTO) in 1994 during the Uruguay Round. It establishes universal, minimum standards of protection that countries must provide for intellectual property (IP) (such as patents, copyright, trademarks, and trade secrets) (Helfer, 2011, p. 33). TRIPS imposes a minimum of 20 years of protection from the date of patent filing (Helfer, 2011, p. 50). The agreement states that countries must "provide for the protection of plant varieties by either patents or by an effective *sui generis* system or by any combination thereof" (Helfer, 2011, p. 50). The term *sui generis* is very vague and it is generally believed that it means each member country can design their own system of protection for plant varieties (Nottenburg, 2012). TRIPS requires WTO members to adopt 'effective' provisions into their national law to permit the enforcement of IP owners' rights (Helfer, 2011, p. 34). TRIPS does not mention anything about the UPOV convention, however, it has stronger legal protection for plant varieties than any other international agreement (Helfer, 2011, p. 33), because the provisions of TRIPS are more detailed and narrow than the compulsory licenses under UPOV 78 and 91 conventions.

"If WTO members choose to protect plant varieties using a *sui generis* right as opposed to a patent, they are required to create a distinct IPR applicable to plant varieties that complies with the core requirements and objectives of the TRIPS Agreement" (Helfer, 2011, p. 54). Under TRIPS, each country has to implement certain mechanisms to protect domestic and foreign varieties. However, local variations of these regulations are possible (Nottenburg, 2012). National governments have a wider variety of options in choosing IPR applicable to plant varieties (Helfer, 2011, p. 21). As of March 2013, there were 159 member states complying with TRIPs through the WTO (WTO, 2014).

Correa (2000, p. 76) argues that there were four major drivers for the implementation of the TRIPS agreement. First, the growing importance of technologies underlying international competition; second, the difficulty of maintaining exclusive knowledge of such technologies; third, reductions in protectionist legislations, facilitating exports without the need of exploiting inventions locally; and finally the falling competitiveness of the United States (US) towards Asian countries, due to piracy and counterfeiting (Correa, 2000).

Countries that are part of the WTO have to comply with TRIPS. Some countries are part of UPOV and other countries are part of both agreements. Being part of both agreements, governments are restricted in national law making, as they have to strictly comply with UPOV and TRIPS at the same time. The UPOV was introduced in 1961 and revised it in 1972, 1978 and 1991. Each convention has slight different regulations. Most countries today are part of UPOV 91. "Both, the UPOV 1991 convention and the 1978 convention adopted the principle of national treatment, the same principle required by TRIPS. However, under UPOV, such treatment need be extended only to the nationals and residents of *other UPOV member states* and to legal persons having their headquarters in such states" (Helfer, 2011, p. 55). The discretion that governments have to shape their PVP depends on the international agreements to which they are parties. There are five groups countries fall into, which are (Helfer, 2011, p. 60):

(1) **WTO only**: These countries have a greater flexibility in policy making than countries belonging to UPOV alone and 95 of 147 WTO members belong to this category (Helfer, 2011, p. 69).

(2) **Either the UPOV 91 convention or the UPOV 78 convention only**: only Russia and Ukraine are part of this category (Helfer, 2011, p. 68).

(3) **WTO and the UPOV 78 convention:** There are 23 countries belonging to this category, including Canada. These countries enjoy a greater discretion due to a more limited protection of PBR contained in this earlier UPOV convention (Helfer, 2011, p. 68).[2]

(4) **WTO and UPOV 91 convention:** These countries have the least discretion and this situation applies to 28 countries, including Australia, UK, France, and the United States. These countries must extend their protection to all plant varieties, comply with the TRIPS most favorite nation (MFN) treatment obligation and adopt the effective enforcement measures. In addition these countries have to comply with all of the other provisions of the UPOV 91 convention (Helfer, 2011, p. 66). For example, because the United States offers patents for plant varieties, it does not need to provide a *sui generis* system as required by the UPOV (Nottenburg, 2012). However, the United States has a second method to patent new plant varieties, which is known as the Plant Variety Protection Act (PVPA). This Act makes patent protection available to new varieties of asexually reproduced plants. The disadvantage, however, is that only one patent option can be chosen to protect a plant variety in each application (Blakeney, 2012).

(5) **No IPR agreement relating to the protection of plant varieties:** Countries falling into this category have no obligation to protect plant varieties or breeders' rights in any form. Countries with a large agricultural sector or plant breeding industry are likely to benefit if their government has a robust IPRs with an array of exclusive rights and few limitations in place. On the other hand, small-scale farming member states will likely prefer weak IPRs with a broad farmers' privilege (Helfer, 2011, p. 77).

2.2.2.1 Benefits of TRIPS Agreement

The following benefits are associated with the TRIPS agreement (Helfer, 2011, p. 39):

(1) It links to other international trade agreements.

(2) It is adhered widely by both the industrialized and the developing world.

(3) It has novel enforcement, review and dispute settlement provisions.

[2] In 2012 France upgraded from UPOV 78 to UPOV 91.

(4) A review of Article 27.3 b., which states that the members of the WTO are allowed to protect their plant varieties by either a patent law, an effective *sui generis* system or a combination thereof (Helfer, 2011, p. 33).

2.2.3 Utility Patents and Plant Patents

In most countries, plant varieties are not patentable. Some countries such as Australia, US and Europe, will allow patenting a trait that is characterized by a single novel gene, invention or transgenic event (ISF, 2011). The variety carrying the trait can then, additionally, be protected by PBRs. In Canada, while plants *per se* are not patentable, plants that contain an innovation at a sub cellular level are patentable. For instance, transgenic canola varieties that contain the Round-Up Ready gene[3] are patentable, whereas, all non-transgenic wheat varieties are not patentable. When plants are not patentable, countries require an alternative mechanism to protect IP. The downside to patents is that the patent holder needs to apply for protection in each different country he wishes to have protection.

In the US, any living organism (product of human intervention) can be patented using utility patents. Utility patent holders have the exclusive right to exploit the trait or to license to third parties. The holder can also exclude all others from using or selling the trait (Blakeney, 2012). The term "utility patent" is used to distinguish between patents and other forms of IP claims. Utility patents in the US are comparable to the standard patents granted in Australia and Europe. Utility patents can be used to claim exclusionary rights in many areas including new variety of plants, transgenic plants, plant groups, individual plants and their descendants, particular plant traits, plant parts, and plant breeding methodologies. In addition, the utility patent grants the owner the right to exclude others from making, using, selling and importing the invention for 20 years (Nottenburg, 2012).

In Europe on the other hand, the European Patent Convention (EPC) considers the UPOV and specifically excludes the patenting of "plant or animal varieties" in addition to the biological processes for the production of these varieties. However, if the process of sexual crossing

[3] The Round-Up Ready gene allows canola to be resistant to the herbicide Round-Up, introduced by Monsanto.

includes a step that introduces a trait into the genome or modifies the trait in the genome of the plant produced, it will not be excluded from the patentability (Blakeney, 2012).

2.3 Contractual (Farmer-Breeder) Protection

Contracts, bag labels, and Technology Use Agreements (TUA) are also used in some countries to protect IPs in plants. These methods of protection are not used as often as PBRs but are shortly explained to provide a more complete understanding.

2.3.1 Contracts

Contracts are used to support PVP. Contracts can, for example, force growers to comply with specific terms set by the breeders. There are only very few international agreements that regulate the law of contracts. Many seed companies will, for example, require producers to sign a contract agreeing not to reseed the second-generation crops. Contracts also capture downstream value by the sale of certified seed (ISF, 2011). Examples of contracts include bag labels, and TUAs:

Bag Labels

Bag label contracts are a way to legally protect plants and seeds in which the purchaser agrees to comply with the contract by opening a bag of seed (Nottenburg, 2012).

Technology Use Agreements (TUA)

TUAs are contracts between technology suppliers and farmers who control the right to plant the seed on a specified area of land for a certain period of time. The seed suppliers reserve the right to inspect the field and to take samples to ensure the compliance of the farmer. The misuse will lead to a breach of contract (Nottenburg, 2012).

As noted above, under UPOV 78 PBRs, breeders have little recourse if a producer who signs a contract or a bag license, violates contract provisions, making these contracts very difficult to enforce. When protected by patents or UPOV 91 PBRs, unauthorized users of protected seed can be held liable for the breached contract term, which greatly enhances enforceability.

2.4 Technical (Private) Protection

Hybrids and Genetic Use Restriction Technologies (GURTs) are technical mechanisms to protect plant. Hybridization is one of the safest methods of protecting PBRs for the breeder. Through hybridization a producer can grow the first generation seeds; the second generation, however, will be almost infertile, making it infeasible for farmers to reseed the harvested seed. This means that it is necessary for producers to buy the certified seed every year so royalties for breeders are guaranteed (ISF, 2011). The cost of hybridization differs substantially by crop. In corn, and canola hybridization is relatively inexpensive and when combined with hybrid vigor is very economic for breeders. In contrast, despite decades of research economically viable hybrid wheat systems have not become widespread. However, the breeder has no enforceable remedy available, except under trade secret law or by contractual agreements (Nottenburg, 2012). Wheat, however, is a non-hybrid and non-genetically modified (GM) crop and, therefore, must rely on PBRs for protection.

2.4.1 Genetic Use Restriction Technologies (GURTs)

The GURTs allows the control of gene expression of an organism, further allowing constraints or restrictions on the use of the organism or trait (Nottenburg, 2012). This is used to strengthen the protection of newly developed plant varieties, which could last for a longer period of time than patents. Variety-level Genetic Use Restriction Technologies (V-GURTs) are used to make the second generation of a crop sterile (also known as terminator gene). This exerts large effects on IPRs.

There are three V-GURT strategies: First, the disrupter gene that blocks the embryo formation as mentioned above. The second strategy uses a chemical to turn off the disrupter gene. If this chemical were unavailable, the gene would express itself after one generation. The third strategy (similar to the second) uses a chemical activator that suppresses the gene that blocks growth (Lence et al., 2005).

2.5 Social Protection

The last category is a protection mechanism that has no legal or contractual background. An example for this that is still widely used in the breeding industry is trade secrets.

2.5.1 Trade Secrets

A trade secret is defined as: "any formula, pattern, device, or compilation of information that is used in a business and gives that business an opportunity to obtain advantages over competitors" (Nottenburg, 2012, section 3). The benefit of using trade secrets to protect new inventions is the unlimited time for protection. Plants can be protected provided that reasonable efforts have been made to keep the plant variety confidential and out of the public domain (Nottenburg, 2012). For instance, a close loop supply-chain may allow the specialized variety to be grown for the delivery to a specific processor. However, once the plant or particularly the plant seed is sold to the public other means of IPRs are required.

2.6 Summary and Conclusion

Figure 2.2 summarizes the four different protection methods presented above.

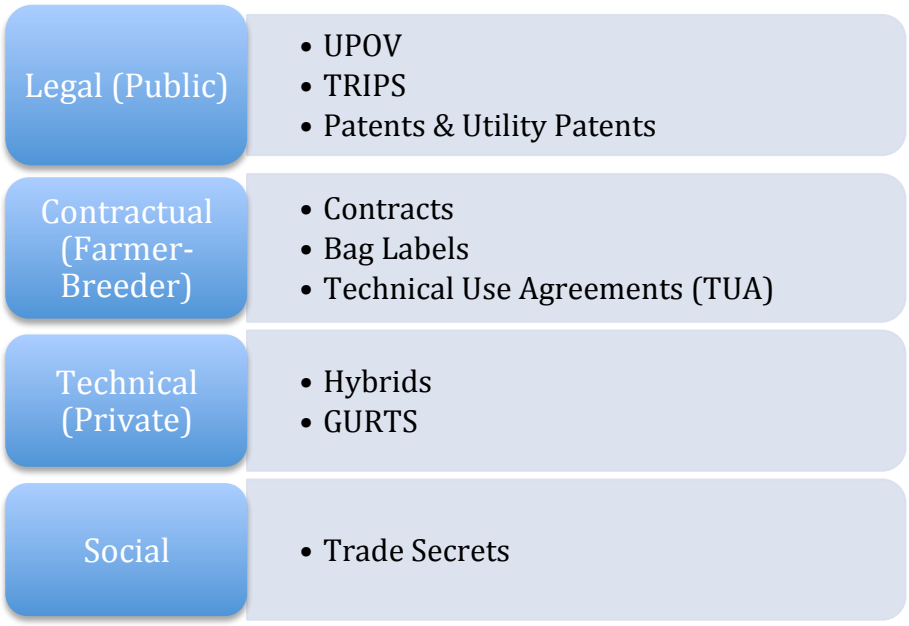

Figure 2.2: IP Protection Summary

Source: author.

Given the many possible ways to enforce property rights, PBRs through UPOV seems to be the preferred method of protection for wheat in many countries. It allows plant breeders to protect a variety in one country and automatically extend protection to all other member countries without having to file for protection in each country. For wheat, France, UK, and Australia have all implemented UPOV 91 in different ways. The following chapters help to understand how the availability of farm saved seed (FSS) affects the ability of breeders to earn

rents from the sale of their new varieties given different implementations of PBRs outlined in this chapter. Each country presented has developed a unique system and has adopted certain exemptions and restrictions in addition to their PBRs regulations. Which PBRs system could improve the Canadian wheat-breeding industry?

3 Theoretical Framework

Social and private benefits vary among different industry structures. In perfect competition, for example, the social benefit, i.e. consumer and producer surplus, is maximized. As competition decreases within a vertical market structure, the producer surplus increases at the cost of the buyers benefit. In this specific case, wheat seed buyers include farmers and downstream consumers of the final product.

3.1 Introduction

The first purpose of this chapter is to create a theoretical framework to help understand how the availability of farm saved seed (FSS) affects the ability of breeders to earn rents from the sale of their new varieties given different plant breeder rights (PBRs).

The second purpose of this chapter is to calculate the average additional annual benefits created through innovation for farmers and breeders. In chapters 4, 5, and 6, the additional annual benefits created in each country are calculated using current royalty rates and increase in production-yield for France, United Kingdom (UK), and Australia respectively. Knowing the additional benefit created, the proportion of the benefit going to farmers and the proportion breeders capture is calculated, which, has implications for private research incentives. With private research and development (R&D), there is often a trade-off between incentives to invest (via reduced competition), which reduces costs and price distortions by raising prices.

3.2 Background

Once knowledge or a new plant variety is protected through intellectual property rights (IPRs), it becomes a "toll good", which is non-rival but excludable (Fulton, 1997). Because wheat-breeding firms have large fixed costs, these firms have economics of size and scale, creating conditions for a less competitive market. In a pure monopoly, price is set where marginal revenue (MR) equals marginal cost (MC). Fulton (1997) points out that because MC is always below average costs (AC), some market power must exist in the industry to cover AC.[4]

[4] Because price is above MC, some deadweight loss (DWL) arises. The extent of market power determines the size of DWL. A monopoly is least desirable, considering market power and the resulting high prices for new wheat varieties. On the other hand, a more competitive industry would reduce seed prices, which increases adoption, but through duplication of effort also

The extent of the market power depends on each country, its legislation, and number of wheat breeding firms. In France, for example, wheat-breeding firms are quite competitive, whereas, in the UK wheat breeding firms have more market power.

The royalty rates charged in the wheat-breeding industry are heavily influenced by the market structure, IPRs, and by the nature of the competition in the industry. I argue that the wheat-breeding industry closely follows the model of a monopolistic competition. The monopolistically competitive model and its underlying assumptions are outlined in section 3.3 and the following sub-sections support my argument.

3.3 Monopolistic Competition

The toll-good industry structure, the distinctness of wheat varieties and substitutability of certified and FSS lead to the model of a monopolistically competitive industry. The assumptions for a monopolistic competitive model are (Church and Ware, 2000; Chamberlain, 1933):

(1) The availability of a large set of **differentiated products;** consumers (farmers) perceive there are non-price differences among the different products.
(2)Even though products are differentiated, they are still close **substitutes** for each other.
(3)**Free-entry condition**; there are no major barriers of entry and exit in the market for wheat breeding. The factors of production are assumed to be perfectly mobile and are used where they are most efficient. The free-entry condition leads to point four where price equals average total cost (P=ATC), which limits profits.
(4)All firms aim for profit **maximization** (MR=MC, then P=ATC), which is their sole objective. Consumers (farmers) aim to maximize their welfare through their purchase.
(5)There are **many producers and many consumers** (farmers) in the market, similar to perfect competition; while the numbers are not infinite, the market is still very competitive.

---

increases the cost of research (Alston et al. 2012). The non-rival aspect of intellectual property (IP) has reduced market competition of the seed industry (Fulton and Gray, 2007), which rules out perfect competition for the wheat-breeding industry.

(6) Firms are largely **price takers** but have a small amount of control over the price they charge. Each firm has their own demand curve, which is relatively elastic but still downward sloping.

(7) **Knowledge** is widely spread between producers (breeders) and consumers (farmers), but is unlikely perfect.

These seven characteristics can be found in the wheat-breeding industry, so the monopolistic competitive model can be used to describe the wheat-breeding industry in countries compliant with UPOV 91. More information on how these characteristics apply to the wheat-breeding industry is given in the following subsections:

3.3.1 Distinctness (Differentiated Products)

Given the requirement for *distinctness* stated by the International Union for the Protection of New Varieties of Plants (UPOV), registered varieties are differentiated by legal requirement. Given that different breeders produce different varieties (see chapter 2), the market structure is consistent the monopolistically competitive model. New varieties differ in many agronomic traits (e.g. disease and lodging resistance, days to maturity, protein content, and many more) and in cost and revenue outcomes depending on specific farm and environmental characteristics of each farmer. As a result, each variety has a downward sloping demand giving the breeder some ability to price above MC. Whenever there is a price setting ability as in a monopoly or with differentiated goods, such as in monopolistic competition, companies price at MR=MC. Figure 3.1 shows all the wheat varieties available for farmers for 2014 in Canada and their characteristics (Government of Saskatchewan, 2014). Figure 3.1 is an example of all the imperfect substitutes available on the market that a wheat breeder needs to consider before introducing a new certified seed wheat variety.

CEREAL CROPS

Wheat

Main Characteristics of Varieties

Category and Variety	Years Tested	Area 1&2	Area 3&4	Irrigation	Protein	Resistance To: Lodging	Sprouting	Stem Rust	Leaf Rust	Stripe Rust	Loose Smut	Bunt	Leaf Spot	FHB	Rel. Maturity (days)	Head Awnedness	Seed Weight (mg)	Volume Wt.[2] (kg/hL)	Ht. (cm)
CWRS[1]		Yield (% AC Barrie)													Relative to AC Barrie				
AC Barrie	11	100	100	100	14.9	G	G	G	P	VP	G	F	P	F	100	N	36.0	79.9	93
CDC Abound	7	109	106	—	-0.3	G	F	VG	P	P	F	F	P	VP	+2	Y	+2.4	-0.3	-10
CDC Alsask §	4	107	106	—	+0.2	F	G	VG	VG	F	G	G	P	P	-1	N	-0.3	-1.3	-1
Alvena	4	105	104	—	+0.2	G	P	G	F	F	G	G	—	P	-2	N	-1.1	0.0	0
AAC Bailey	3	103	103	—	-0.3	G	G	VG	VG	—	P	G	F	F	-2	N	+0.3	-3.0	0
AAC Brandon[1]	2	109	105	—	-0.6	G	P	VG	VG	G	G	P	F	G	+1	Y	-0.5	-1.8	-12
Carberry	5	109	103	—	-0.1	VG	F	G	VG	G	G	VG	P	G	+3	Y	+1.2	+1.2	-12
Cardale[1]	4	102	105	—	+0.1	G	G	VG	VG	G	F	G	P	G	+1	Y	-3.3	0.0	-9
AAC Elie[1]	2	108	103	—	-0.5	G	F	VG	VG	G	F	F	F	F	+1	Y	-0.3	-1.6	-13
AC Elsa §	7	103	104	97	-0.1	G	F	VG	G	F	G	F	F	P	-1	N	-2.4	-0.5	-1
Fieldstar VB[3]	9	111	110	—	-0.3	F	VG	G	VG	P	F	F	F	F	0	Y	-2.1	+0.7	+3
Glenn	5	107	107	—	-0.5	VG	F	VG	VG	G	F	F	F	F	+3	Y	-1.7	+1.9	-4
CDC Go	4	102	103	—	-0.1	G	P	VG	F	G	P	F	VP	P	-1	Y	+3.6	-0.3	-6
Goodeve VB[3]	9	111	111	—	0.0	VG	G	G	G	F	G	P	F	VP	-2	N	+0.8	-0.9	-2
Harvest	6	101	104	—	-0.4	VG	VG	VG	G	G	G	VP	P	VP	-1	N	-0.4	+0.1	-6
CDC Imagine §	5	98	102	—	-0.1	G	F	F	F	F	G	G	P	VP	0	N	-1.7	-1.8	-3
Infinity	8	107	107	—	-0.2	G	G	G	G	P	G	G	G	VP	-1	N	-2.8	-0.6	-1
AC Intrepid	5	101	104	102	-0.3	G	P	G	G	G	F	G	P	P	-3	N	-0.2	-0.4	-2
KANE §	5	104	104	—	-0.2	G	VG	VG	VG	G	P	F	F	F	+1	Y	-0.5	+1.4	-5
CDC Kernen	5	110	109	—	-0.1	G	P	G	G	F	VG	F	F	F	+1	Y	+1.3	-0.1	+3
Lillian	7	101	98	—	+0.3	F	G	G	VG	VG	F	G	G	VP	0	N	-0.3	-1.1	-1
CDC VR Morris[1]	3	113	111	—	-0.3	G	P	G	VG	—	F	F	F	G	-1	N	-2.3	+0.7	-2
Muchmore	5	115	103	—	-0.5	VG	G	VG	VG	G	G	VG	P	P	+3	Y	+1.3	0	-15
CDC Osler §	3	101	104	—	-0.3	G	F	VG	G	F	G	G	F	F	-1	N	-3.7	-0.7	-2
CDC Plentiful[1]	3	111	109	—	-0.3	VG	P	VG	VG	G	VG	F	P	G	-1	N	-2.9	-0.3	-4
AAC Redwater[1]	2	105	102		-0.3	G	VG	VG	VG	G	P	F	P	F	-2	Y	-3.3	-3.1	-5
Shaw VB	5	121	119	—	-0.7	G	G	VG	G	F	VP	G	P	P	+1	N	-0.4	-1.6	+5
CDC Stanley	5	114	112	—	-0.2	G	G	VG	G	F	G	VP	F	P	0	N	-2.2	-1.1	-3
Stettler	6	114	110	106	+0.1	G	G	G	P	G	VG	G	P	P	+1	Y	-0.6	0.0	-6
SY433[1]	3	101	110	—	-0.3	G	VG	VG	VG	—	F	VP	F	G	0	Y	+0.1	-1.7	+2
CDC Thrive	5	110	111	—	-0.1	G	F	G	F	F	G	F	F	P	0	N	-0.5	0.0	+1
Unity VB[3]	9	118	119	—	-0.7	F	VG	G	VG	P	P	VG	F	F	0	Y	-0.6	+1.0	+1
CDC Utmost VB[3]	5	119	116	—	-0.5	G	G	G	VG	F	P	VP	F	P	-1	N	-0.5	-0.1	-3
Vesper VB[1,3]	4	117	116	—	-0.9	F	F	G	VG	VP	F	VP	P	F	0	Y	+0.9	-1.2	-1
Waskada	9	117	112	108	-0.3	F	VG	VG	F	P	G	VG	P	G	+1	Y	+0.3	+1.4	+4
WR859 CL	6	111	104	108	-0.2	G	G	G	VG	F	VG	VG	P	G	0	Y	-2.2	0.0	-7
5602HR §	6	103	104	—	+0.1	F	F	VG	VG	F	VG	G	P	G	+1	Y	0.0	+1.6	+1
5603HR[1]	5	113	112	—	-0.7	G	VG	G	VG	P	P	F	G	F	+3	Y	-2.7	-2.0	+1
5604HR CL[1]	5	105	102	—	-0.8	G	G	VG	VG	—	P	F	P	F	-1	Y	-2.5	-0.3	-2
5605HR CL[1]	2	105	112	—	0.2	G	—	P	G	—	VG	G	P	G	+1	Y	-2.0	-0.3	-2
Hard White Spring[1]																			
AAC Iceberg	2	105	101	—	-0.9	G	P	VG	VG	F	P	F	P	F	0	Y	+2.5	+0.7	-8
Snowbird §	5	99	102	—	-0.6	G	G	G	F	P	G	P	P	F	0	N	-1.8	-0.4	+1
Snowstar	4	105	107	—	-1.2	VG	G	VG	G	P	P	VP	P	P	-1	N	-5.2	+1.2	-9
AAC Whitefox	2	105	111	—	-1.2	VG	—	G	G	P	P	P	P	F	-1	N	-1.2	+0.4	0
Whitehawk	3	103	97	—	-1.0	G	G	F	VG	P	F	P	P	P	-2	N	-4.1	+0.3	-5
CDC Whitewood	2	98	99	—	-0.5	G	G	G	G	F	VP	VP	P	F	0	Y	-0.8	-0.1	-10
Soft White Spring[1]																			
AC Andrew	5	138	135	—	-3.6	G	P	G	P	F	VP	VP	F	F	+5	Y	+0.7	-1.8	-9
AAC Chiffon	2	152	140	—	-4.1	G	VP	VP	F	G	VP	VP	—	VP	+5	Y	+5.6	+1.2	+1
Sadash	5	146	134	—	-4.3	VG	P	G	F	VG	F	VP	F	VP	+5	Y	+0.7	+0.6	-6

Wheat (cont'd)

Category and Variety	Years Tested	Area 1&2	Area 3&4	Irrigation	Protein	Resistance To: Lodging	Sprouting	Stem Rust	Leaf Rust	Stripe Rust	Loose Smut	Bunt	Leaf Spot	FHB	Rel. Maturity	Head Awnedness	Seed Weight (mg)	Volume Wt.[2] (kg/hL)	Ht. (cm)
CPSR[1]		**Yield (% AC Barrie)**													**Relative to AC Barrie**				
Conquer VB[3]	5	124	124	—	-1.5	F	P	VG	G	G	P	VG	F	P	+1	Y	+9.6	+1.8	-4
AC Crystal	11	118	115	110	-1.3	VG	P	VG	P	VP	P	VG	F	VP	+3	Y	+4.9	-0.1	-11
Enchant VB	3	117	116	—	-1.5	F	G	G	VG	VP	G	VG	P	VP	+1	Y	+16.8	+1.5	-5
AAC Ryley	2	113	115	—	-1.6	G	G	VG	VG	VP	F	VG	P	P	0	Y	+12.8	-0.9	-11
SY985	4	113	111	—	-0.8	G	P	VG	VG	—	VG	G	F	F	+1	Y	+10.1	+0.4	-15
5700PR	5	115	119	115	-1.2	VG	F	VG	F	P	P	VG	P	P	+2	Y	+6.8	+1.1	-16
5702PR	6	126	124	—	-1.6	G	P	F	G	P	P	F	G	P	+1	Y	+8.5	0.0	-10
Canada Western Extra Strong[1]																			
Burnside	6	98	100	—	-0.1	F	G	VG	VG	VG	VG	F	P	VP	0	N	+3.6	-0.4	+6
Glencross VB[3]	4	110	118	—	-0.6	F	F	VG	G	—	VG	F	P	VP	-1	N	+7.2	-2.5	+7
Canada Western General Purpose																			
AAC Innova	3	145	136	—	-3.6	G	VP	G	VG	VG	VP	VP	F	VP	+6	Y	+2.4	-1.8	-7
CDC NRG003	5	128	124	—	-2.0	G	G	VG	P	—	P	VG	VP	VP	0	Y	+6.4	-1.8	-10
NRG010	5	129	127	—	-2.6	G	F	VG	VG	VG	P	VG	P	P	+2	Y	+3.3	-2.0	-7
Pasteur	3	143	137	—	-2.6	VG	G	G	VG	G	P	VP	F	F	+8	N	+2.9	+0.9	-7
AAC Proclaim	2	129	128	—	-2.8	F	F	G	VG	P	G	VP	F	G	+4	Y	+0.8	+0.3	+10
CWAD		**Yield (% Strongfield)**													**Relative to Strongfield**				
Strongfield	6	100	100	100	14.5	F	F	VG	VG	G	P	VG	F	VP	105	Y	42.1	79.2	89
Brigade	5	109	112	110	-1.2	G	F	VG	VG	G	P	VG	F	P	+2	Y	+1.1	+0.3	+6
AAC Current	2	101	95	—	0.0	F	F	VG	VG	G	P	G	F	VP	0	Y	+1.0	+1.0	+4
CDC Desire	2	102	100	—	-0.2	F	G	VG	VG	G	P	VG	F	VP	-2	Y	-3.0	-0.1	0
Enterprise	5	103	101	106	-0.2	F	G	VG	VG	VG	P	G	F	P	0	Y	-3.2	+0.6	+2
Eurostar	5	100	104	102	-0.5	F	F	VG	VG	VG	P	VG	F	P	+2	Y	+0.6	+0.8	+4
CDC Fortitude	2	107	102	—	-0.2	VG	—	G	VG	G	P	VG	P	P	+1	Y	-2.0	0.0	-1
AAC Marchwell VB[3]	2	102	109	—	-0.4	F	—	VG	VG	VG	G	VG	P	P	0	Y	-2.7	-0.6	0
AC Navigator	6	98	90	—	-0.7	G	G	VG	VG	VG	P	VG	VP	VP	+2	Y	+1.2	-0.1	-8
AAC Raymore	2	96	96	—	0.2	F	F	VG	VG	G	P	G	F	VP	-1	Y	-0.1	-0.1	0
Transcend	4	102	103	94	-0.3	F	G	VG	VG	VG	P	VG	F	P	+2	Y	-1.4	0.0	+8
CDC Verona	5	102	104	103	-0.3	G	F	VG	VG	VG	P	VG	F	P	+2	Y	+0.1	-0.2	+1
CDC Vivid	2	105	99	—	-0.2	G	F	VG	VG	G	F	VG	F	VP	0	Y	-0.6	-0.2	0

[1] Includes direct and indirect comparisons with AC Barrie
[2] multiply by 0.8 = lbs per bushel
[3] VB varietal blend

Figure 3.1: Wheat Varieties for Western Canada, 2014

Source: Government of Saskatchewan, 2014.

3.3.2 Substitutes

The different varieties of (Canada Western Red Spring) CWRS wheat available to farmers, shown in Figure 3.1, are all somewhat substitutable with each other. Farmers will switch variety depending on the characteristics they are looking for and depending on royalties charged by the breeders. If a variety would suddenly double in price, farmers would have many other varieties they could switch to.

The demand facing the breeder of the new variety is very dependent not only on the quality of the innovation, but also the availability of substitutes in the market place. As the owner of distinct variety, each breeder faces a downward sloping demand curve but the demand curve or the willingness to pay shifts lower as substitutes become more available. The demand curve may

even have a zero price intercept if other superior varieties are freely available. The downward sloping demand curve facing each breeder reflects the monopolistically competitiveness of the product. This demand curve is shown in the top right hand panel of Figure 3.2, Figure 3.3, and Figure 3.4.

3.3.3 Free Entry

Some countries have a privatized wheat-breeding industry (e.g. UK), some are public (e.g. Canada) and others are a mix of public and private firms (e.g. France). In each of these industries, there are low barriers to entry as different breeders produce different wheat varieties. There is a changing demand by farmers for new wheat varieties with different characteristics, so there is potential for new breeders to meet that certain demand. The PBRs outlined in UPOV 91 allow breeders to use existing varieties to breed new varieties through the breeders' exemption. This exemption encourages market entry and innovation.[5]

3.3.4 Numerous Producers (Breeders) and Consumers (Farmers)

There are 193 registered spring wheat varieties, 130 winter wheat varieties and 25 durum varieties in Canada (CFIA, 2014), and 60,749 wheat farmers (AAFC, 2010). Even though many wheat varieties are available, only a few public institutions are involved in the wheat-breeding sector in Canada. Given these statistics, it is apparent that there are many differentiated wheat varieties produced (by very few institutions) and many farmers on the market that want to purchase wheat. As opposed to a perfectly competitive market, this market is less competitive.

3.3.5 Price Takers

In some markets, wheat breeders are restricted on how much they can charge for royalties. There is enough competition by the other wheat breeders and by the presence of FSS a year later, such that royalties cannot be set too high. In addition, in some countries, governments or breeders' and farmers' unions can set royalty rates exogenously (e.g. France and UK). In other markets wheat breeders have more control over royalty rates settings, but still need to consider other breeders and crops on the market.

[5] Even though there are no legal barriers to entry, new breeding companies still face barriers to entry due to the high fixed costs (FC) of entering a market and strict licensing terms for variety registration.

3.3.6 Knowledge

Knowledge is assumed to be widely available, such that wheat breeders know what characteristics their varieties have compared to competitors products. Wheat breeders also know what competitors charge for royalties. Farmers are also informed through public testing and variety guides, publications or other sources which varieties are available, their characteristics and the prices for each. An example of such information is given in Figure 3.1.

3.3.7 Summary

In a monopolistic competitive market, firms have more market power than in perfect competition but less than in a monopoly case. How much market power there is depends on the country, their legislation, and their number of wheat breeders. In the following chapters, each country is analyzed individually. Given the distinctness of products and the ability to set prices on their own demand curve, firms face an industry that has more market power than perfect competition.

Including Farm Saved Seed (FSS) to the Model of Monopolistic Competition

With UPOV 91 plant breeders' rights (PBRs), farmers have access to farm saved seed (FSS). Because of the *stability* requirement for variety registration, FSS is genetically a virtually perfect substitute to certified seed of the same variety. By adopting a new variety, the farmer either purchases enough certified seed for the whole farm or purchases a small quantity of certified seed to produce enough FSS for the next year. Because wheat is open pollenated, once tested, cleaned, and treated, it allows farmers to reuse FSS for many years.

By choosing to purchase only a small quantity of certified seed and growing their own FSS, farmers must forego the benefits of the new variety for one year as they grow seed. The existence of this perfect substitute and the relative pricing of certified and FSS royalties can provide some insight into the competitive structure of the industry. In particular, how the royalty structure for FSS influences the royalties charged for certified seed and the overall royalty income of breeders.

As a general rule, the breeder does not determine the royalty charged on FSS. In most countries (e.g. Canada, U.S.A), there is zero a royalty on FSS. In France and the UK, FSS

royalties are exogenously set either through the government or by breeders' and farmers' unions, whereas, breeders freely set the royalties on certified seed in the UK. The exception to this general rule exists in Australia, where the breeder sets a common End Point Royalty (EPR) that applies equally to production from FSS and certified seed. The relationship between FFS and certified seed pricing is shown graphically in the next section.

3.4 Graphical Analysis – Monopolistic Competition with FSS

Consider the breeding and sale of a new crop variety. Assume the breeder has invested the necessary resources to develop a new variety and has registered this variety using PBRs. If granted PBRs, the breeder has the exclusive right to sell the seed of the variety for a specified amount of time (20 years for wheat), which enables it to charge a royalty.

Assume also that the following conditions hold:

(1) All farmers have the same portfolio of land characteristics. The greater is the land area planted; the lesser is the marginal productivity on this land.

(2) Farmers differ in their marginal cost (MC) of producing FSS. The costs of acquiring certified seed to save and store as FSS, FSS preparation costs (storage, transportation, seeding, harvesting) for growing FSS are included as opportunity costs. Because the MC curve is different for each farmer, it is upward sloping. This also implies that the farmer that produces FSS the cheapest, likely uses FSS only. Other farmers, to whom the reproduction of FSS is the greatest, likely grow certified seed only.

There are two different ways in which FSS and certified seed royalties are charged. Subsection 3.4.1 shows what happens when certified seed and FSS have a different royalty (e.g. France and UK), whereas, subsection 3.4.2 shows what happens when certified seed and FSS have the same royalty (e.g. Australia). It is important to note that different property rights lead to modifications of the model.

3.4.1 Incomplete Property Rights – Different Royalties for Certified and FSS

Figure 3.2 shows how the exogenously set FSS royalties impact what a breeder can charge for certified seed. This figure represents an individual firm in the total wheat-breeding market and can be applied to the UK and French wheat-breeding industry.

The farmer has a downward sloping demand curve because he can choose between different varieties. His demand depends on prices and availability of other varieties on the market. Once he chooses a variety (i), he has the choice between purchasing certified seed or/and using FSS of this same variety (i). If they choose certified seed, he must purchase the seed from a certified seed grower. Because the FSS royalty usually is lower than the certified seed royalty, some farmers may wish to use their own FSS. To do so they must purchase a small quantity of certified seed and incur the costs to grow it on their farm, test it, clean it, treat it for use, plus pay any FSS royalty due. With the latter option, the farmer must forego the additional rents earned from the variety (i) for one year while he grows FSS.

Bottom right hand panel:

This panel shows the FSS royalty which is exogenously set by the farmers' and breeders' unions (in France) or predetermined and based on historical royalty rates (in the UK).

Middle right hand panel:

The total marginal cost (TMC) of producing FSS is the vertical sum of the opportunity cost mentioned above plus the MC of producing FSS (MC_{FSS}). The MC includes the cost of growing the FSS, seed testing, seed cleaning and treatment, and the opportunity cost is the forgone yield gain for one year. Once incurring these additional costs, farmers have access to the variety (i). The MC_{FSS} curve is upward sloping as different farmers have different costs of producing FSS and are ordered from those with the lowest to highest MC of producing FSS. Producing FSS might be quite cheap for a large farmer but can be expensive (i.e. due to cleaning and storage costs) for smaller farmers. This increasing MC_{FSS} curve helps differentiate the farmers in the model.

Upper right hand panel:

This panel shows the total demand curve for the variety (i) equals to the value marginal product (VMP). This VMP reflects the additional revenue variety (i) generates on each parcel of land. The total farmer demand for variety (i) is the sum of the demand for FSS and certified seed for variety (i). The demand curve shows the maximum price farmers are willing to pay (WTP) for a given quantity of the variety. It is important to note that each of the breeders faces a total demand for their product. The total demand is dependent on the availability and prices of other

varieties in the market. This demand curve determines that the wheat-breeding industry is monopolistically competitive. The supply curve is the sum of the *TMC* (middle right hand panel) and the FSS royalty (shown in the bottom right hand panel).

Upper left hand panel:

Given supply curve of FSS and the total demand for the new variety (*i*) (top right hand panel), the demand for certified seed can be derived as a derived residual demand (upper left hand panel). The price intercept of the derived residual demand for certified seed is at price of intersection of supply of FSS and total demand for variety (*i*).

Middle left hand panel:

This panel shows the price that seed services charge to produce certified seed. Seed production services are assumed to be competitively priced, meaning that this sector does not incur any profits and prices at P=MC. Further research needs to be conducted to analyze the competitiveness of this sector.

Bottom left hand panel:

The demand for certified seed faced by the breeder consists of the derived residual demand for certified seed (upper left hand panel) minus price charged by seed growers for certified seed services (middle right hand panel). The breeder facing this demand curve, sets the certified seed royalty. If breeders wish to maximize royalty revenue, they set MR=MC as the wheat-breeding industry is monopolistically competitive. MC of certified seed for breeders is zero, because once they have created a new variety, producing any additional output results in no additional costs. The intersection of MR=MC shows the optimal quantity of certified seed produced (shown in the left panels).

Equilibrium Price and Quantity:

Moving back up to the upper left hand panel, the intercept of the quantity demanded for certified seed and the derived residual demand curve shows the price (*P*) charged for the certified seed. Plotting this price in the upper right hand panel shows the quantity of FSS supplied and the total quantity demanded for variety (*i*) at the given price (*P*). The difference between total

quantity demanded and quantity of certified seed purchased is the quantity of FSS purchased (bottom right hand panel).

Welfare Impacts:

The top right panel shows the total surplus to farmers[6] and downstream users using FSS (green triangle) and certified seed (i.e. farmers' benefit from producing variety (*i*)). The benefit of using FSS is the area above the price of certified seed and below the total market demand curve for variety (*i*). The benefit from using certified seed is the green triangle above the supply curve and below the price for certified seed charged, as farmers reproduce their own FSS.

The bottom right panel shows the royalty revenue for the FSS use of variety (*i*) to breeders (yellow rectangle). The bottom left panel (yellow rectangle) labels the total royalty revenue breeders get from the sale of certified seed, which is labeled as a surplus7.

The middle left panel shows the price of certified seed charged by the seed growers, net of the royalty charge paid to breeders. Because seed growers are assumed to be competitive in this model, they do not receive any profits.

It is important to note wheat-breeding companies have some degree of market power and may keep some of the benefit as profits. If their surplus is not invested back into research, it might not lead to a large productivity growth. This scenario is what is happening in the UK (see chapter 5).

[6] The surplus to farmers also includes the economic surplus to consumers and all other downstream market participants.
[7] Breeders face fixed costs (FC) of maintaining a variety once it is registered, such quality maintenance. Zero approximates the marginal cost (MC) of wheat breeders.

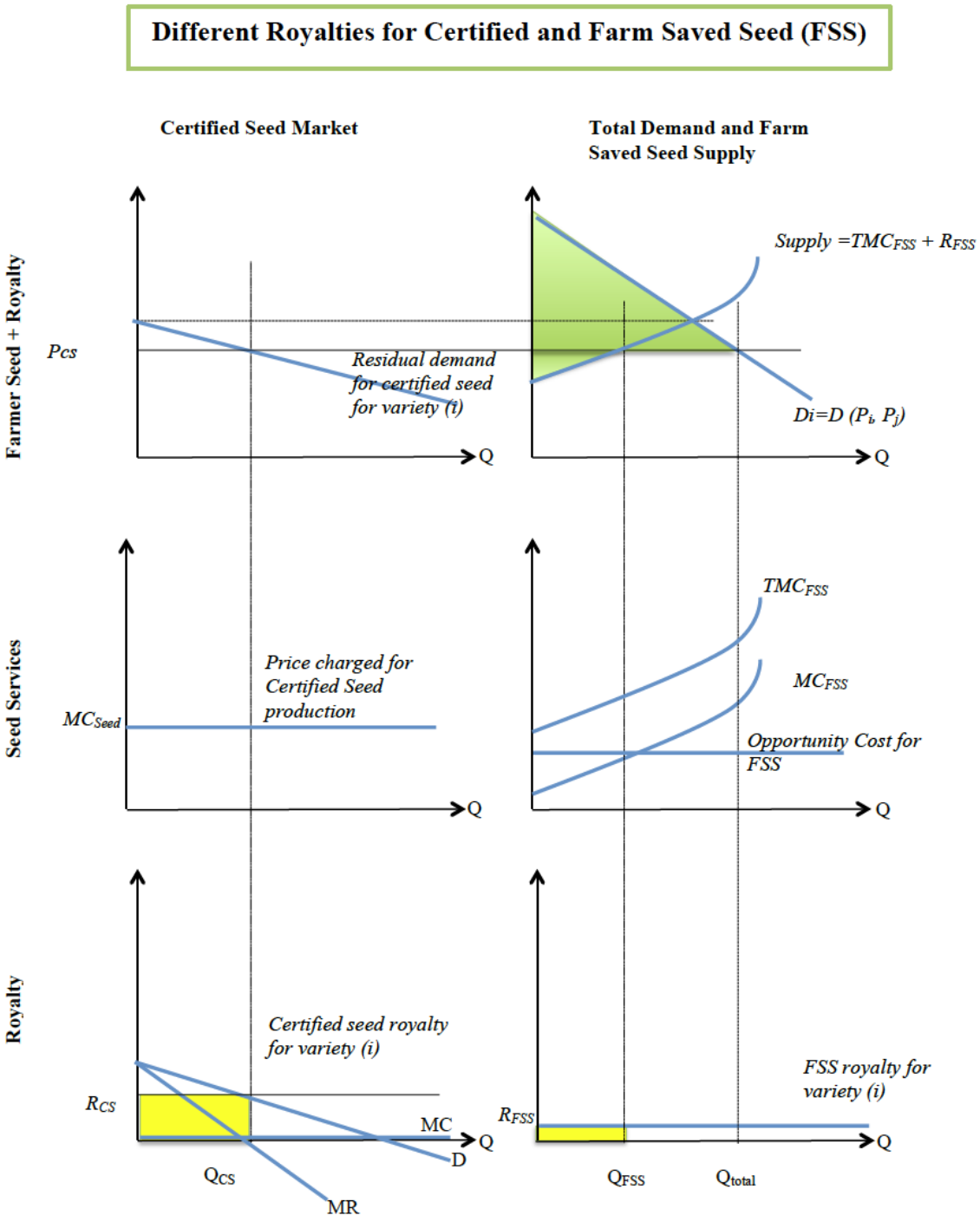

Figure 3.2: Market for Certified and Farm Saved Seed

Source: author.

3.4.1.1 Application: Increase in the FSS Royalty

The higher FSS royalty is set; the higher certified seed royalty can be set. Figure 3.3 shows the impact of an increase in the royalty charged on FSS.

Bottom right hand panel:

The increase of the FSS royalty leads to an increase of the certified seed royalty (bottom left hand panel) and the demand for certified seed (shifts upward). Hence, certified seed breeders like a higher FSS royalty. The revenue of the FSS royalty is decreased for the breeder due to less farmers choosing to produce FSS (however, this depends on the elasticity of demand)[8], whereas, revenue for the certified seed is increased.

Middle right hand panel:

The cost of production for FSS for the farmer remains unchanged.

Upper right hand panel:

The supply curve for FSS shifts up because the royalty cost for FSS has increased. The supply curve is the sum of the *TMC* plus the royalty cost of FSS. Because the total demand for the variety stays the same, the intercept of supply and demand has increased, leading to a higher WTP for certified seed.

Upper left hand panel:

The demand curve for certified seed has increased because the WTP for certified has increased since FSS has become more expensive.

Middle left hand panel:

The seed producers charge the same price as previously because they are competitive.

[8] It is important to note that the elasticity of demand for wheat plays a role in these models. However, the countries analyzed are very small players on the world market and even if they would double their output, it would not change the price, so breeding efforts and productivity increases are important. The elasticity of demand in the world for wheat is very low, whereas, in the country itself, it is very elastic. An elastic demand means that farmers and breeders capture most of the benefits created by the national breeding programs.

Bottom left hand panel:

The derived residual demand for certified seed facing the breeders has increased and so has the quantity for certified seed demanded, which decreases the quantity demanded for FSS (upper right hand panel).

Equilibrium Price and Quantity:

Royalties for certified seed and FSS have both increased so farmers are faced with a higher price (*P*) for both sources of seed. The supply curve for variety (*i*) has shifted up.

Welfare Impacts:

The top right panel shows the surplus of farmers and downstream users using FSS (green triangle), i.e. farmers' benefit from producing variety (*i*), which has decreased compared to the scenario of a lower FSS royalty. The area is enclosed by the supply curve for FSS and the total market demand curve for variety (*i*).

By charging a FSS royalty, farmers, however, benefit by way of the breeders, who get a higher benefit and have more funds available. If breeders reinvest this money for research, farmers benefit through increased variety yields and better qualities. If a FSS royalty is very low or non-existent (see chapter 7, Canada), breeder revenue is very limited.

The bottom right hand panel shows the royalty revenue for breeders for the FSS sale of variety (*i*) (yellow rectangle), which has decreased dramatically compared to a lower FSS royalty, however again, this is very much dependent on the elasticity of demand for this variety itself and the demand elasticity for certified seed. The bottom left panel shows the royalty revenue for certified seed (yellow rectangle), which has increased.

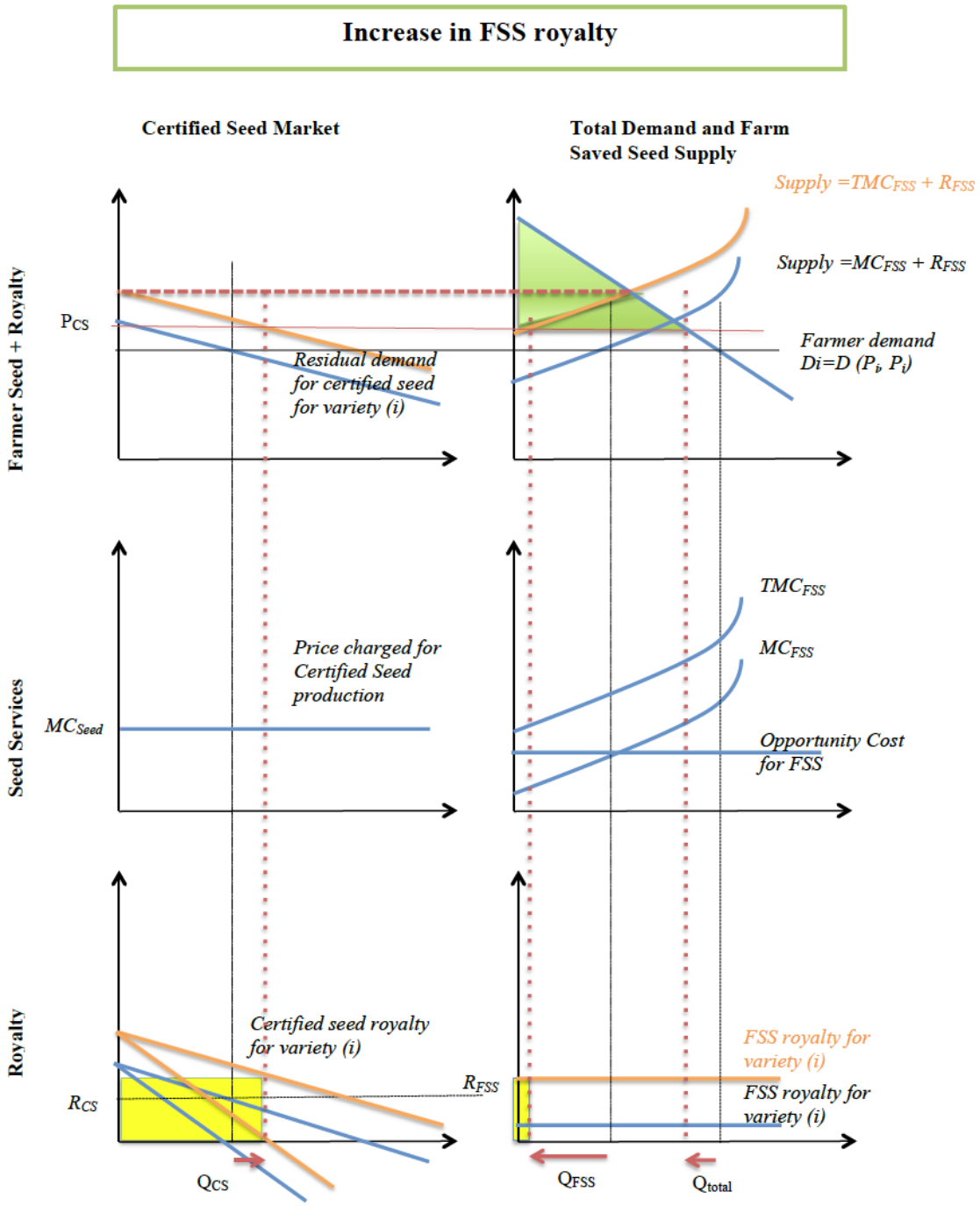

Figure 3.3: Impact of a Change in FSS Royalty

Source: author.

3.4.2 Complete Property Rights – Homogeneous Royalties for Certified and FSS

The 1994 PBR Act in Australia allows the breeders to set a common EPR royalty for both certified and FSS. When FSS and certified seed have the same royalty, there is not a great incentive for farmers to wait a year for a specific variety.

The Australian industry is a modified version of the model applicable to France and the UK. Australia is also different because once a royalty is set for a variety; it will never change (i.e. FSS and certified seed royalties are the same for the same variety) for the length of time of the PBR protection (20 years). Figure 3.4 shows the six-panel model for Australia.

Middle left hand panel:

The middle left hand panel shows the marginal cost (MC_{CS}) of seed production faced by seed producers. It is linear because it is independent of the quantity produced as seed producers are assumed to be competitive.

Middle right hand panel:

The middle right hand panel shows the supply curve of FSS. The supply curve consists of the MC of the seed growers (MC_{CS}) (middle left hand panel) and the MC of farmers to reproduce their own seed (MC_{FSS}). As mentioned earlier, MC_{FSS} is increasing to differentiate farmers. The kink in the supply curve is present because the MC_{CS} is flat, and so MC_{FSS} will not go higher than the MC_{CS}. Farmers choose the cheaper expense. The opportunity cost of using FSS and foregoing the additional yield for a year is included and added to have a *TMC* of producing FSS.

Upper right hand panel:

The *TMC* curve and the royalty for FSS are added to get the total supply curve for the variety (*i*). This panel also shows the total demand for variety (*i*). The intersection of total demand and total supply show the total quantity of variety (*i*) produced.

Upper left hand panel:

The total demand minus the supply of FSS shows the derived residual demand for certified seed faced by the farmer.

Bottom left hand panel:

This panel shows the derived residual demand for certified seed faced by the breeder, which consists of the total derived residual demand for certified seed minus the price charged by the seed producers. The royalties charged for certified seed are also shown here. Note the royalty for FSS is the same as for certified seed. The kink in the demand curve creates a discontinuous marginal revenue (MR) curve for royalties. The monopolistic competitive breeder sets the royalties at MR=MC=0, as shown in the bottom left hand panel. MC of producing additional certified seed of a new wheat variety is zero for breeders as explained earlier.

Bottom right hand panel:

This panel shows the total demand for FSS. It is kinked because farmers choose to purchase FSS up to the kink, as it is cheaper for these farmers (i.e. MC_{FSS} is equal). After this point, farmers switch to certified seed. The total demand for the variety is shown in this panel as well.

Welfare Impacts:

The benefits for the breeders from certified seed sales are shown as the yellow rectangle in the bottom left hand panel enclosed by the horizontal aspect of the demand curve up to where the kink is located. The rectangle enclosed by the FSS royalty up to the kink in the bottom right hand panel depicts FSS sales. The benefits for farmers and downstream users are shown in the top right hand panel (green area) enclosed by the demand curve and above the supply curve.

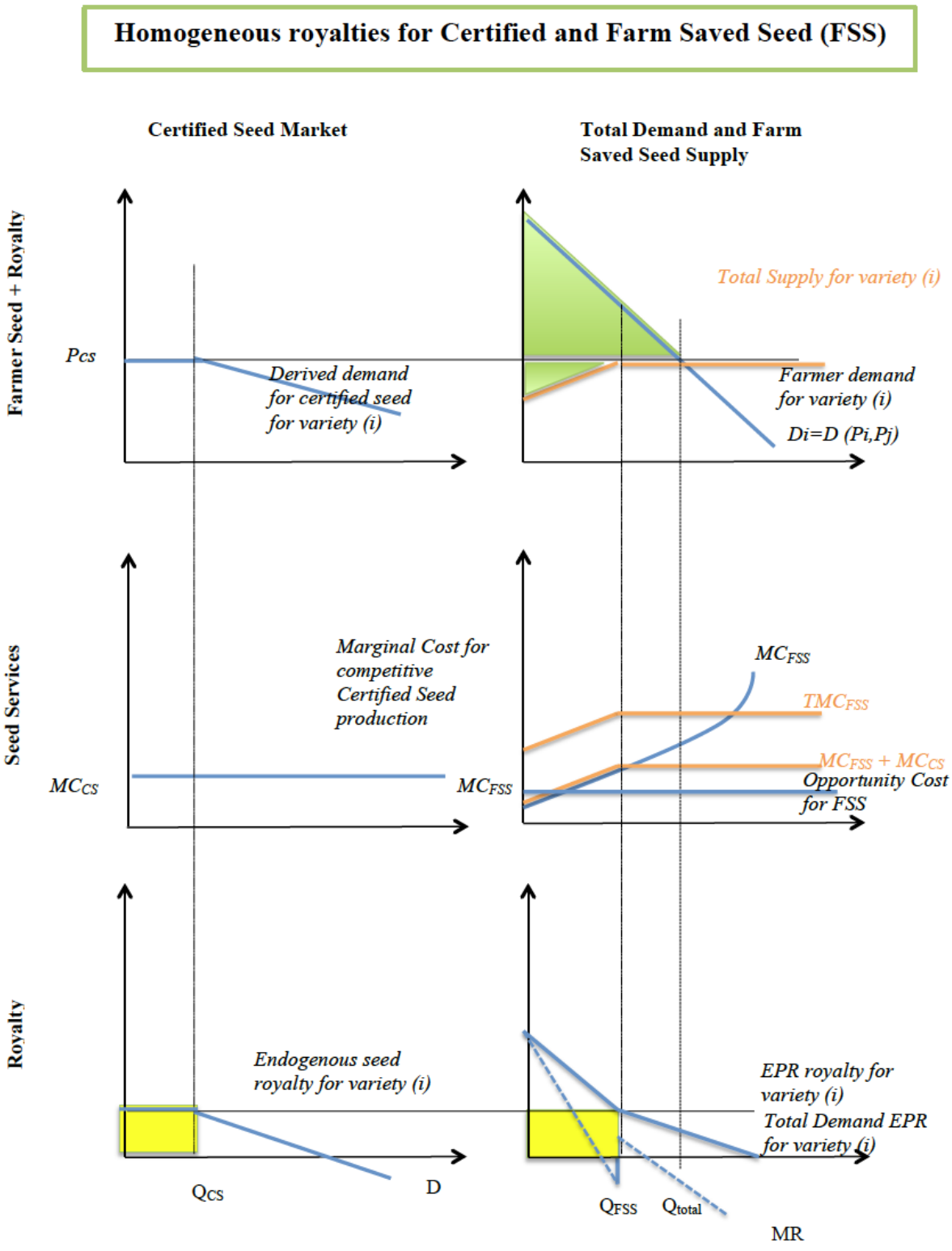

Figure 3.4: Certified and FSS pricing

Source: author.

3.5 Surplus Distributions of New Varity Adoption

Given complete property rights, normal surpluses for consumers and producers occur. Often, however, intellectual property rights (IPRs) are lacking in strength or are incomplete, so research and development (R&D) activities within private firms generate benefits above the normal surpluses that are enjoyed by farmers and downstream consumers. This excess of social rate of return over the private rate of return is often described as a spillover (Jaffe, 1996). Because private firms make decisions based on their private rate of return, they often do not undertake research, which would be socially desirable (Jaffe, 1996).

In this thesis, I compare the additional annual benefits created for farmers and breeders through innovation and varietal improvement. The benefits to breeders and farmers are calculated using the yield increases per year and world price. Depending on the royalty breeders charge for new varieties, I can identify what portion of the benefit created by the new varieties is captured by the breeders (private benefit) and which portion transfers to farmers and downstream users (social benefit) due to incomplete property rights. The benefit to breeders is the annual royalty revenue for the new variety, which is known. The benefit to farmers is the total additional benefit minus the benefit to the breeders. The total additional benefit is then divided by the total production to get a benefit of $/ton of production. Theory suggests that private benefits are higher, the stronger the IPRs are in each country. The benefit analysis in this study only considers royalty investment and revenue. It excludes any public and levy funding. Also, the benefits calculated are gross benefits. Farmers still have to consider additional costs of producing a new variety.

4 France

France is the fourth largest producer and exporter of wheat in the world, surpassed only by China, India and the United States (US) in production (FAOSTAT, 2013). France produces about 36 million tons of wheat per year in total, averaging 7.2 tons per hectare, which is high compared to other countries. Wheat is a major contributor to the French economy with a positive balance of trade of more than $5.52 billion (Wheat Initiative, 2013). Figure 4.1 shows the proportion of wheat grown compared to the next five large crops in France. It is apparent that wheat and sugar beet have the highest production output in tons.

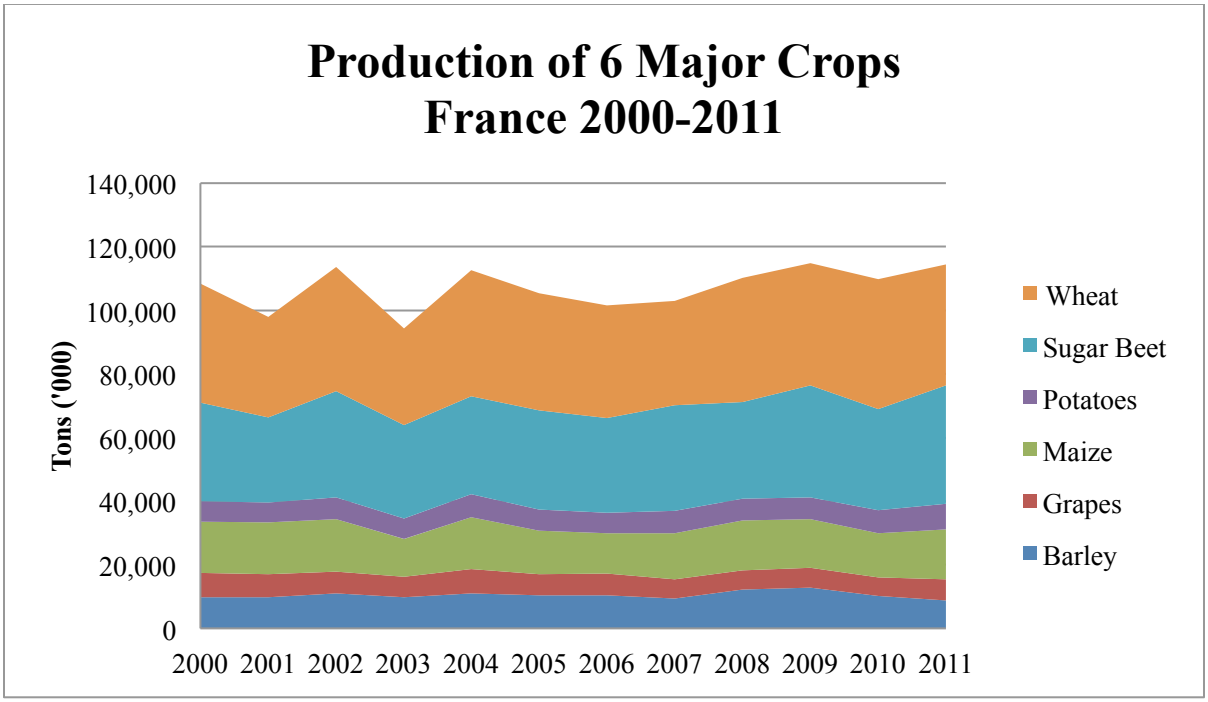

Figure 4.1: Production of Six Major Crops in France

Source: FAOSTAT, 2013.

France has 12 main private wheat-breeding firms that make up a very competitive seed market, namely Bayer CropScience, Biogemma, Limagrain Europe, RAGT Semences, Florimond-Desprez, Lemarie-Deffontaines, Secobra Recherches, Momont, Saaten Union, Syngenta, Caussade-Semences and Agri-Obtentions S.A. (Wheat Initiative, 2013). Private firms dominate wheat breeding in France. However, the Institut National de la Recherche Agronomique (INRA), which is a public institution, collaborates with universities and manages a breeding program in conjunction with its research programs through Agri-Obtentions (Wheat

Initiative, 2013). The two largest breeders, Limagrain and RAGT Semences, which combined make up 60-70 percent of the market, are cooperatives and are owned by farmers. Only about 30 percent of the market share belongs to international companies such as Bayer or private family companies such as Momont. Cooperatives also control a large part of the seed production and all other services such as chemicals sales (Interview 1, 2012). Durum wheat, which represents only about ten percent of production and is grown mostly in southern France, has three main breeders: RAGT Semences, Florimond-Desprez and Limagrain.

In France, winter bread wheat is known as 'blé tendre'. Blé tendre is French and translates to the English word soft wheat; however, it cannot be mistaken for feed wheat, which in English is also called soft wheat. To avoid confusion, I refer to blé tendre as bread wheat. Given the importance of and high demand for bread wheat in France, this chapter focuses on bread wheat only. Most of the wheat breeding in France is done on winter bread wheat for three main reasons. First, wheat breeders can capture royalties on farm saved seed (FSS) on these varieties only;[9] second, the price of feed wheat is well below the price of bread wheat; and third, breeders are thus rarely breeding feed wheat anymore since the demand faced from farmers is very low (Interview 2, 2012).

In this chapter, I begin with some background on France's wheat-breeding industry and indicate which national and international regulations apply to the royalty structure for farmers and wheat breeders. In section 4.2, I briefly describe the history of France's wheat-breeding industry and how it has developed the current royalty collection mechanism described in section 4.3. In addition, I outline the major players involved in variety registration and royalty collection for France specifically. In subsection 4.3.3, I explain how France collects royalties on certified seed and on FSS. In subsection 4.4.1, I calculate the average additional annual benefit created through the introduction of new wheat varieties, and the proportion of the benefit going to farmers and breeders from the innovation. A brief summary concludes this chapter.

[9] Starting in the production year of 2014, royalty collection on FSS is not limited to bread wheat anymore; France expands the royalty collection mechanism to all crops.

4.1 Background

Section 4.1 explains the regulations France has adopted to ensure royalty collection on FSS, focusing in particular on the legislation provided by the International Union for the Protection of New Varieties of Plants (UPOV). In this section, I also explain how the French bread wheat sector is structured, how royalty rates are determined, how the revenue is collected, and ultimately how these plant breeders' rights (PBRs) enable a viable private seed industry.

4.1.1 Intellectual Property Rights (IPRs)

Over the course of the past 45 years, France has taken steps to remain compliant with the UPOV convention. Historically, the pattern of compliance started as France joined the UPOV on October 3, 1971, to become compliant with the UPOV 1961 convention. On March 17, 1983, France passed legislation to become compliant with the UPOV 1978 convention (UPOV, 2005), and since May 27, 2012, France is compliant with UPOV 91 (UPOV, 2012).

Under UPOV 78, farmers had the right to save seed to replant for subsequent crops and sellers of certified seed were obligated to collect royalties on the sale of varieties, which were then remitted to the variety owner, the breeder (Gray et al. 2013, p 17). In addition to UPOV, France is also a member of the World Trade Organization (WTO) and must also comply with the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS). Please see chapter 2 for in-depth information on UPOV 61, 78, 91 and TRIPS.

4.2 Historical Development of Wheat Royalty Collection

In the past, farmers have always saved seeds from their harvest to sow in subsequent years. Until recently, however, only users of certified varieties took part in funding plant improvement research through royalties in France (UPOV, 2013). According to Société Coopérative d'Intérêt Agricole des Sélectionneurs Obtenteurs de Variétés Végétales (SICASOV), until 1993, farmers had the right to save seed "for reproduction on condition that plant breeders' legitimate interests are safeguarded" (SICASOV, 2013). Since 1994, farmers were allowed to keep FSS for reproduction on their own land but are obliged to pay royalties on bread wheat. In 2001, the Association Générale des Producteurs de Blé (AGPB), the association of wheat producers and SICASOV, representing breeders, reached an agreement on vegetal variety enhancement for bread wheat, which opened up new prospects (France Agricole, 2007). This agreement has been

renewed twice since (SICASOV, 2013). This farmer-breeder agreement for a FSS royalty is only applied to bread wheat varieties and no other crops. After passing the 2012 PBRs Act, as France became compliant with UPOV 91 convention, all wheat varieties are subject to a FSS royalty starting in crop season 2014.

4.3 Current Wheat Royalty Collection System

According to SICASOV wheat breeding requires a long-term commitment. It takes more than ten years to certify and produce a new variety. Because it takes such a long time in addition to intensive capital investment, it was necessary to create a system that permits cereal production to become more attractive to wheat breeding companies. The bread wheat agreement between SICASOV and the farmers unions enabled France to achieve such a system (SICASOV, 2013).

4.3.1 A Brief Overview of Varietal Registration

It is compulsory to register wheat in France if it is sold on the market. IPRs for wheat can be garnered in two ways: (1) through national registration (Contribution Volontaire Obligatoire (CVO), known as Compulsory Voluntary Contribution in English) level by direct filing with the National Plant Variety office and (2) through the European Union (EU) Community Plant Variety Office (CPVO) (CVV level). The Plant Varieties Protection (PVP) Act defines PBRs legislation for France specifically through UPOV (PVP Gazette 33, 1983). The duration of registration for bread wheat lasts for 20 years in France, starting from the date on which the certificate was issued (Paritypatent, 2013).

Once a breeder applies for registration, the variety is tested in the EU and is also checked for novelty, distinctness, uniformity and stability (DUS), further described in chapter 2. Once it satisfies DUS requirements and shows Value of Cultivation and Use (VCU) it is registered in the official catalogue and becomes automatically transferred to the common catalogue at the EU level. VCU generates information to predict variety behavior nationally and abroad, and determines whether a variety can be grown economically (i.e. have some value in cultivation in use) (NIVAP, 2013).

The cost of registering a new wheat variety in France is approximately $9,660, which is much cheaper than it is in the rest of Europe. Registration in Germany costs about $27,600 to

$41,400 per variety of wheat. The comparatively low cost in France incurs because the INRA is paying a portion of the salaries at the Technical Committee for Plant Breeding (CTPS). CTPS is an organization between INRA and the Chamber of Agriculture and is in charge to define registration criteria and long-term objectives for different groups of crops (Interview 3, 2012).

4.3.2 Institutions Involved in Royalty Collection

There are two main institutions involved in royalty regulation and collection in France, Groupement National Interprofessionnel des Semences et plants (GNIS) and SICASOV.

Groupement National Interprofessionnel des Semences et plants (GNIS)

Groupement National Interprofessionnel des Semences et plants (GNIS) is a national association representing plant breeders created in 1999 that has the responsibility of seed certification, verification, licensing growers and inspecting seed production in France. The Service Officiel de Contrôle et de Certification (SOC) is the official regulatory body within GNIS with the responsibility for official seed certification in France (ESCAA, 2013). GNIS is composed of representatives from all professions related to plant breeding, seed production, seed growth, seed distribution, farming and other interested parties. The propositions from GNIS are submitted to the Ministry of Agriculture for official approval (Genoplante (organization), 2010).

Société Coopérative d'Intérêt Agricole des Sélectionneurs Obtenteurs de Variétés Végétales (SICASOV)

Société Coopérative d'Intérêt Agricole des Sélectionneurs Obtenteurs de Variétés Végétales (SICASOV) is a cooperative owned by plant breeders, enforces IPRs and collects seed royalties (Gray et al. 2013, p. 17). SICASOV operates on a "declarative system" based on forms sent to seed growers. Each year seed growers apply to SICASOV for license agreements to grow certified seed indicating the variety and area of seed crops they wish to produce. Based on this information, SICASOV sends invoices to seed growers who declare the quantity of seed produced and remit royalties to SICASOV. SICASOV collects these seed royalties on behalf of breeders (ISF, 2012) and pays for this expense. SICASOV also sets the certified seed royalty rate. Seed growers have the incentive to accurately declare their seed production because GNIS is in charge of seed inspection and shares seed certification data with SICASOV, which makes it easy for SICASOV to detect any mis-declaration.

4.3.3 The Royalty Collection System

In France, certified and FSS royalty rates and collection mechanisms are different. The different royalty rates and money flows are described below.

Farm Saved Seed (CVO) Royalty Flow:

The royalties on FSS are collected via end point royalty (EPR), known as Contribution Volontaire Obligatoire (CVO) in France, which is applied at the point of sale to all bread wheat varieties. The €0.50 ($0.69)[10] per ton EPR applies to all bread wheat varieties and is collected through the seed marketers at the point where the farmers deliver their harvest.[11] This CVO facilitates and reduces the cost of collection for GNIS and SICASOV (Alston et al. 2012, p. 32).

As shown in Figure 4.2, the marketers charge the farmer the CVO at the time of the wheat delivery. GNIS is responsible for the collection of the FSS royalty from the marketers and then redistributes the money (1) back to farmers, which fall under the small farmer exemption (producing less than 92 tons per year), (2) back to breeders, in direct proportion of certified seed sales, and (3) forward the rest of the money to SICASOV. Breeders get reimbursed 85 percent of the FSS royalties and SICASOV forwards the remaining 15 percent to Fonds de Soutien a l'Obtention Végétale en blé tendre (FSOV), which is the French wheat research fund (Alston et al. 2012 p. 32). Because both sources of royalties go back to breeders, 100 percent of the royalties collected were considered in the following calculations.

Certified Seed Royalty Flow:

Figure 4.2 also shows the money and information flow for certified seed. Breeders get paid a royalty from the sale of certified seed for their variety. The certified seed royalty rate is identical across all bread wheat varieties at €75 ($103.50) per ton, and is paid for when farmers purchase their seed from a seed grower (SICASOV, 2013). The seed growers declare certified seed sales and remit payment to SICASOV. SICASOV invoices and receives payment for declared certified seed sales, verifies the amount paid and reimburses the breeders. SICASOV and GNIS exchange information for verification purposes. GNIS inspects fields and seeds of seed growers. The CVO

[10] The exchange rate for Euros to USD is 1 to 1.38 as of April 15, 2014.
[11] The CVO is increased to €0.70 ($0.97) per ton starting in the growing season of 2014 (SICASOV, 2013).

of €0.50 ($0.69) per ton is also charged to the farmers that use certified seed at the time of delivery to a marketer. However, as opposed to FSS, farmers that provide receipts of certified seed purchases receive a refund of €20 ($27.60)[12] per ton of seed purchased, whereas FSS users do not get any refund at all.

[12] The refund is increased to €28 ($38.65) per ton of bought seed starting in the growing season of 2014 (SICASOV, 2013).

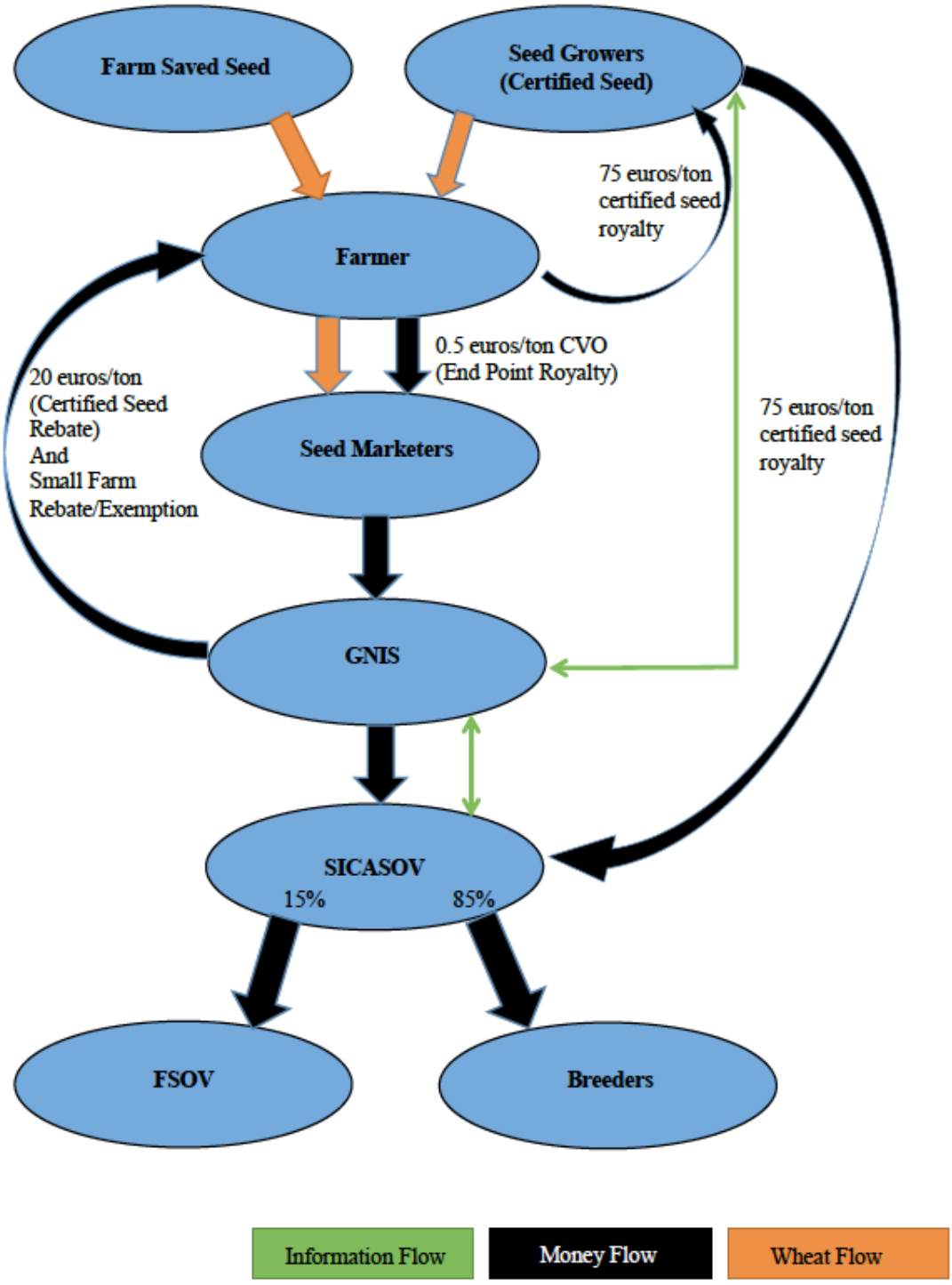

Figure 4.2: Certified and FSS Royalty and Information Flows

Source: SICASOV, 2013

4.3.4 Efficiency of Royalty Collection

According to the International Seed Federation (ISF), the French royalty collection system allows SICASOV to collect almost 100 percent of the royalties due on certified seed in addition to 90 percent of the FSS royalties (ISF, 2011). The other ten percent fall under the small farmers' exemption or is consumed on the farm. The ISF grades the French royalty collection system at about 92 percent efficient on bread wheat (ISF, 2011). However, efficiency can be interpreted in different ways. The system efficiency is different if looked at the perspective of the breeder or the farmer. The bottom line is that the system is well enforced and most farmers pay the royalties due. A broader context of efficiency should consider the transfer of surplus from breeders to farmers due to incomplete property rights from the average additional benefit created of varietal improvement, which is addressed in section 4.4.

4.3.5 Annual Royalty Revenue

Approximately 50 percent of wheat seed in France is farm saved. The collection and contribution to breeders works as follows. On sales of 36 million tons, grain marketers remit $24.84 million in royalties to GNIS (Gray and Galushko, 2013 p. 16). The sector is funded from $41.4 million in certified seed royalties plus about $12.42 million in FSS royalties, $53.82 million in total (Gray and Galushko, 2013, p. 13).

4.4 Conceptual Framework

To calculate the average additional annual benefit created through varietal improvement and its distribution, I am using the average yield increase per and the world price of wheat. The results are outlined in the following tables including the breeders' benefits, and the transfer of surplus to the farmers due to incomplete property rights.

4.4.1 Analysis: Additional Benefits from Varietal Improvement

The average additional annual benefit from the introduction of a new wheat variety can be calculated, including the share of the benefits going to the breeders and to the farmers. Table 4.1 shows the parameters for France. Note that the parameters are given on a per hectare basis and also per metric ton of seed, as different reader groups might be interested in different measurement units. These parameters are held constant throughout the calculations presented in the subsequent tables.

The certified seed royalty (row 6) in France is set at €75/ton ($103.50/ton) and the EPR for FSS, also known as the CVO (row 5) is set at €0.50/ton ($0.69/ton). The refund farmers receive (row 7) if they purchased certified seed royalty (i.e. they paid the royalty twice) is €20/ton ($27.60/ton). To facilitate the understanding of the following tables, I calculated the total price of certified seed (row 8), which is the royalty for certified seed plus the EPR minus the refund. For further explanation on the royalty rates, please refer to subsection 4.3.3.

Table 4.1: Parameters for France

Parameters for France				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
1	Seeding rate (t)		0.1613	1.00
2	Average wheat yield (t)		7.20	44.64
3	Yield gain (t per year)	1.81%	0.13	0.81
4	World wheat price ($)	$ 316.52		
5	EPR CVO rate ($/t wheat sold)	$ 0.69	$ 4.97	$ 30.80
6	Certified seed royalty ($)		$ 16.69	$ 103.50
7	Refund for certified seed purchase ($)		$ 4.45	$ 27.60
8	Net Cost of Certified Seed ($)	5+6-7	$ 17.21	$ 106.70

Sources: [1] www.uky.edu/Ag/Wheat/seedrate.html
[2,3] U.N. Food and Agriculture Organization, FAOSTAT, 1961-2010 electronic database at faostat.fao.org, updated 7 August 2012; and U.S. Department of Agriculture, World Agricultural Production 2011-2012 (Washington, DC: January 2013)
[4] International Grains Council (April 15, 2014)
[5,6,7] SICASOV, 2013

Table 4.2 shows the annual gross revenue farmers receive from the average additional benefit created by the introduction of a new variety. The average additional annual benefit (row 9) of $41.15/hectare (ha) or $255.10/ton of seed is calculated by multiplying the yield gain per year (row 3) with the world wheat price (row 4).

By subtracting the royalty cost to the farmer (rows 10 and 11) from the additional benefit created (row 9) I get the additional annual gross innovation revenue for the farmer (row 12). According to this calculation, the farmer gets $30.06/ha or $186.35/ton of seed from the additional benefit created.

Table 4.2: Revenue for French Farmers

Additional Annual Revenue for French Farmers				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
9	Gross Revenue from Innovation ($)	3*4	$ 41.15	$ 255.10
	Cost of Royalty ($)			
10	FSS	50% of 5	$ 2.48	$ 15.40
11	Certified Seed	50% of 8	$ 8.61	$ 53.35
12	Add. Innovation Revenue for Farmers ($)	(9-10-11)	$ 30.06	$ 186.35

Source: author.

Table 4.3 shows the gross additional revenue for the breeders and the administration costs (if applicable) associated with the introduction of a new variety. The additional income for the breeders (row 13) is the total royalty revenue of $11.09/ha or $68.75/ton of seed. Therefore, the cost to the farmer is the benefit to the breeders (rows 10 and 11). The breeders, however, get 15 percent of the FSS royalties through FSOV, which is a research fund (row 14) and 85 percent directly from the FSS royalties (row 15). There is no administration cost in France.

Table 4.3: Revenue for French Breeders

Additional Annual Revenue for French Breeders and Administration Costs				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
	Income from Royalty ($)			
10	FSS	50% of 5	$ 2.48	$ 15.40
11	Certified Seed	50% of 8	$ 8.61	$ 53.35
13	Total Royalty Revenue for Breeders ($)		$ 11.09	$ 68.75
14	Amount through FSOV ($)	15% of 5	$ 0.37	$ 2.31
15	FSS Revenue to Breeders ($)	85% of 5	$ 2.11	$ 13.09

Source: author.

Table 4.4 shows the benefit distribution in percentages. Farmers get most of the benefit at 73 percent (row 15). Breeders get 27 percent (row 16) and there are no administration costs (row 17) being taken off the royalty income in France.

Table 4.4: Benefit Distribution of the Innovation

Benefit Distribution				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
16	% Benefit to Farmer	(12/9)	73%	73%
17	% Benefit to Breeder	(13/9)	27%	27%
18	% Administration Cost		0%	0%

Source: author.

Interpretation:

On average, farmers get 73 percent of the average additional benefit created from the new variety. Breeders only capture 27 percent of the additional benefit created. Farmers receive a large portion of the additional benefit created through innovation at no cost.

Figure 4.3 shows the results attained in Table 4.4. It shows the additional annual benefit created in dollars per ton of production. It takes into consideration the average increase in quantity produced per year (650,000 tons), which is calculated by the total tons of soft wheat produced in France, times its average yield increase per year and the commodity price of wheat, set at $316.50/ton. Knowing that wheat breeders in France get about $53.82 million of royalties per year in total, representing about 27 percent, leaves the farmers with a benefit of 73 percent.

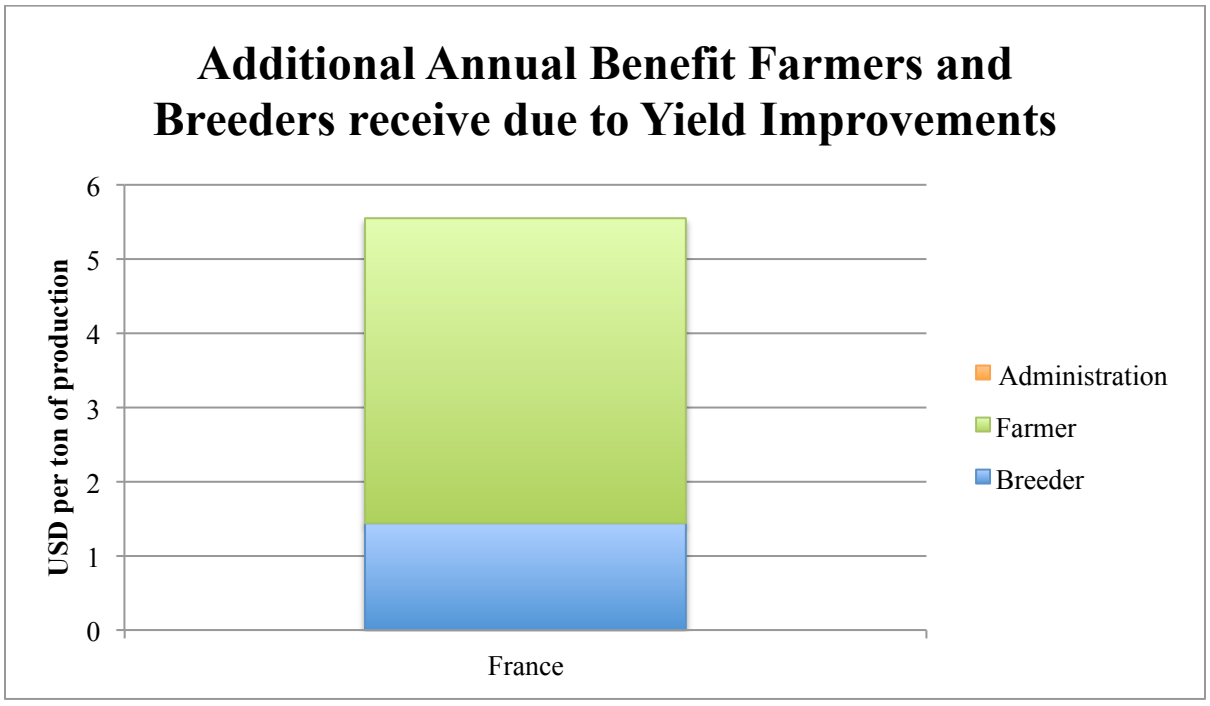

Figure 4.3: Additional Annual Benefits for Farmers and Breeders in France

Source: author.

It is important to note these benefits are in addition to the normal benefits for farmers and breeders. These benefits are created through innovation and are calculated as return over variable cost. Farmers still need to consider additional costs, (increased cost of production due to an

increased yield, different seed costs, search costs, transportation and storage, riskiness, and agronomic differences) which they can pay for from this additional benefit.

4.5 Graphical Analysis

In France, farmers purchase about 50 percent FSS and 50 percent certified seed. Annual royalty revenues are outlined in subsection 4.3.5 and royalty rates are outlined in Table 4.1. Please see chapter 3, subsection 3.4.1 for further explanation of the model.

The government determines the FSS royalty exogenously. Starting in year 2014, France is increasing their royalty rates for FSS as well as for certified seed. This increase leads to a higher supply curve for FSS and an increased derived residual demand for certified seed. This analysis is also outlined in chapter 3, subsection 3.4.1.1.

4.6 Discussion and Conclusion

The French wheat royalty collection system works well and provides benefits for farmers and breeders. Farmers capture a higher share of the additional annual benefits created than breeders, which shows that breeders have fewer funds available for future investment in breeding. A higher FSS royalty rate can benefit breeders as that allows them to increase the certified seed royalty.

5 United Kingdom

Wheat is the most important crop to the United Kingdom (UK) with crop breeders earning approximately $28.4 million per year in royalties (Galushko and Gray, 2013). About 65 percent of cropping land is sown to wheat, where the average UK wheat crop yields about 15 million tons in total or about 8 tons per hectare. The UK wheat production has tripled since the 1960s and according to the British Society of Plant Breeders (BSPB), 90 percent of the yield gain can be attributed to plant breeding (BSPB, 2011). Since 1990, yields have stagnated and production has leveled out (Galushko and Gray, 2013). National Association of British and Irish Millers (NABIM) Groups 1 and 2 hard wheat varieties make up 29 percent of total UK wheat production while the most grown varieties are soft milling types (Group 3). Production of high quality wheat is not sufficient to meet the requirements of the UK bread-making industry so additional high-protein wheat is imported, mainly from Canada (Galushko and Gray, 2013). Figure 5.1 shows the proportion of wheat grown compared to the next five large crops in the UK. It is apparent that wheat and sugar beet have the highest production output in tons.

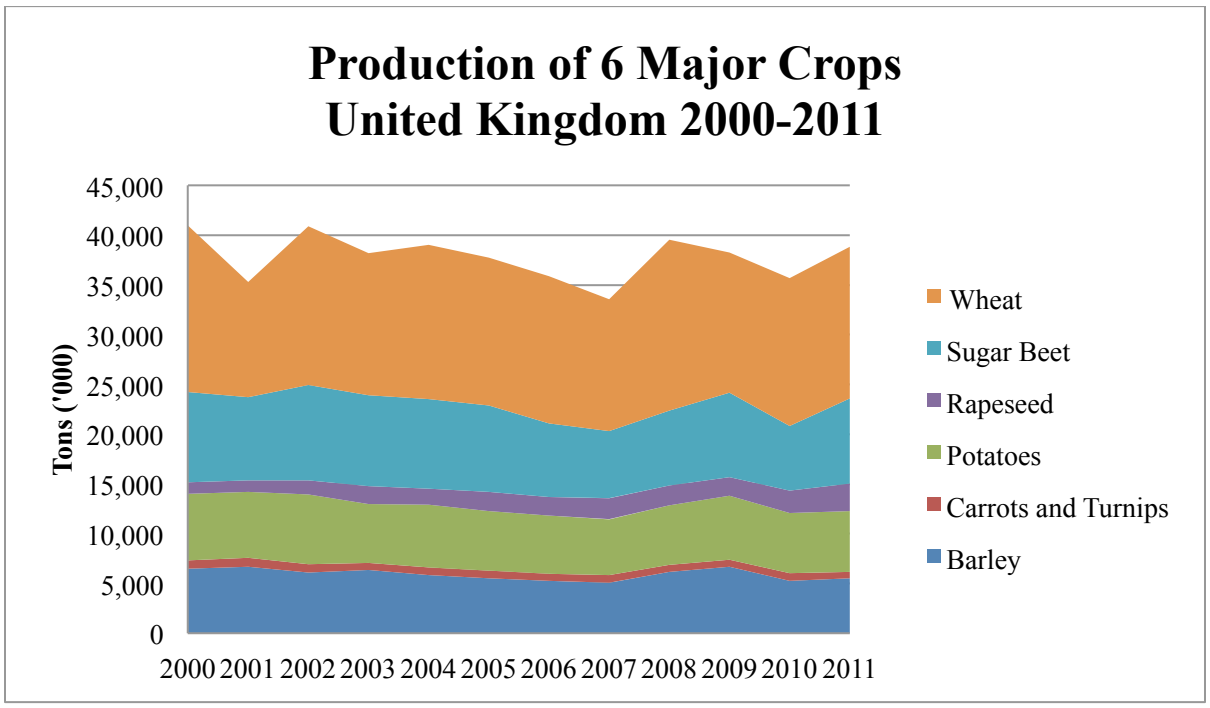

Figure 5.1: Production of Six Major Crops in the UK

Source: FAOSTAT, 2013

Wheat breeding was predominantly publicly funded until 1987. In that year, the Plant Breeding Institute (PBI) in Cambridge was sold to Unilever, a private company, and that was the

end of public wheat breeding. Today, the leading wheat breeders in the UK are Limagrain UK Ltd., KWS US Ltd., RAGT UK Ltd., and Syngenta UK Ltd., holding the majority of the market share. There are also smaller private companies present, including DSV (Deutsche Saatveredelung AG) UK LTD., and Saaten Union UK Ltd. (Galushko and Gray, 2013).

While the public sector no longer breeds commercial wheat varieties, public wheat research continues. Centers for public wheat research include two universities; the University of Bristol and the University of Nottingham, and two research institutes; the Rothamsted Research Limited and the John Innes Centre in Norwich (Galushko and Gray, 2013, p. 18). The current role of the public sector provides fundamental research that feeds into the private breeding programs (Galushko and Gray, 2013).

In this section, I begin with the background to the UK's wheat-breeding industry and indicate which national and international regulations apply to the royalty structure for farmers and wheat breeders. In section 5.2, I briefly discuss the history of the UK's wheat-breeding industry and how they have developed their current royalty collection mechanism described in section 5.3. In addition, I outline the major players involved in variety registration and royalty collection for the UK specifically. Subsection 5.3.3, explains how the UK collects royalties on certified seed and on farm saved seed (FSS). Finally, in section 5.4, I calculate the average additional annual benefit created through the introduction of new wheat varieties, and the proportion of the benefit going to farmers and breeders from the innovation. A brief summary concludes the section.

5.1 Background

Section 5.1 explains the regulations the UK has adopted to ensure royalty collection on FSS, focusing in particular, on the legislation provided by the International Union for the Protection of New Varieties of Plants (UPOV). In this section I also explain how the UK wheat sector is structured, how royalty rates are determined, how the revenue is collected, and ultimately how these plant breeders' rights (PBRs) enable a viable private seed industry.

5.1.1 Intellectual Property Rights (IPRs)

The UK has kept up with current forms of PBRs, based on the principles of the International Union for the Protection of New Varieties of Plants (UPOV). In 1964, the UK passed the UK

Plant Variety and Seeds Act to become compliant with UPOV 1961. Since then, the UK has adapted its PBR to remain compliant with changing UPOV agreements and EU PBR legislation. In 1994, the EU passed legislation to become compliant with UPOV 91, allowing breeders to charge a royalty on FSS as long as it is "sensibly lower" than the royalty on certified seed (McKee, p. 10, 2003). The 1997 UK Plant Variety Act allows the UK to be compliant with 1994 EU PBR legislation in addition to UPOV 91 (Galushko and Gray, 2013). In addition to UPOV, the UK has been a member of the World Trade Organization (WTO) since 1995 and complies with the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS).

5.2 Historical Development of Wheat Royalty Collection

In the past, farmers have always saved seeds from their harvest to sow in subsequent years. Privatization of public crop breeding in the UK was undertaken to increase total research investment. Looking at the UK wheat research today, some would think there was a smooth transition from public to private breeding; however, there were significant challenges in establishing the UK wheat-breeding system (Galushko and Gray, 2013).

The Plant Breeding Institute (PBI) held a dominant position for over 75 years in UK wheat research and breeding and its wheat varieties still hold about 80 percent of market share. Gray and Galushko (2013) conducted interviews throughout the UK to get a greater understanding of its wheat-breeding system. During an interview conducted with a representative from a British wheat breeding company, a breeder said: "With the privatization of plant breeding in the UK, the development of elite lines went into the private sector, while a broad scale developing of pre-breeding material almost stopped. Pre-breeding activities fell outside of what the private sector was willing to do as these activities are considered long-term, risky, and generally not yielding sufficient rewards" (Galushko and Gray, 2013 p. 27). "The goal of the pre-breeding program is to have public researchers involved in the development of novel germplasm that can then be introduced by the private breeders into their elite lines. Germplasm developed in the pre-breeding program is publicly available and is free of IP" (Galushko and Gray, 2013 p. 28).

5.3 Current Wheat Royalty Collection System

5.3.1 A brief Overview of Varietal Registration

In order to market a variety within the UK or in the European Union (EU) in general, plant breeders have to register the variety through national testing systems either in the UK or within the EU. The UK breeders usually register the varieties through the UK system. In order to be sold as certified seed, a variety must be on the national list. To be eligible for the national list a variety must meet the usual criteria of distinctiveness, uniformity, and stability (DUS) outlined by UPOV. In the UK, the BSPB organizes the variety trials for the national list (Galushko and Gray, p. 30, 2013). Importantly, these variety trails are conducted cooperatively using private breeders. This allows the breeders to see how their varieties perform relative to the varieties of their competitors; it is an important conduit for knowledge sharing. Variety testing goes on for two years to ensure the variety has Value for Cultivation and Use (VCU). About 40 varieties are added to the national list per year.

A second and very important step in commercializing a variety in the UK is achieving the recommended list of varieties. The Home Grown Cereal Authority (HGCA), a producer funded organization, develops the recommended list. To be eligible for the recommended list, a variety must meet a number of merit criteria based on an extensive set of field and quality trials. The new variety has to have at least a two percent yield benefit compared to the current yield potential, or an additional attribute than already found in current available varieties (Galushko and Gray, 2013). Typically, less than 8-12 new varieties per year make the recommended list. Because the recommended list has additional merit criteria, producers rely heavily on the list for variety selection.

5.3.2 Institutions Involved in Royalty Collection

The two main institutions involved in royalty regulation and collection in the UK are the British Society of Plant Breeders (BSPB) and the National Institute of Agricultural Botany (NIAB).

British Society of Plant Breeders (BSPB)

British Society of Plant Breeders (BSPB) Ltd., to which all plant breeders are members, plays a central role in royalty collection. The BSPB has four main roles; (1) organizing variety trials, (2) representing the UK plant breeding industry, (3) informing farmers the importance of wheat breeding, and (4) collecting royalties (Galushko and Gray, 2013). BSPB licenses the production and sale of certified seed and collects royalties on certified seed and FSS. BSPB also contacts farmers twice a year reminding them the importance of supporting plant breeding and paying royalties, since the royalty collection mainly relies on the goodwill of farmers (Galushko and Gray, 2013). BSPB is a not for profit organization, funded by a retention of the royalty it collects, memberships, and license fees. It represents 56 members from the public and private sector crop breeders in the UK (BSPB, 2011).

National Institute of Agricultural Botany (NIAB)

The National Institute of Agricultural Botany (NIAB) is an independent and not-for-profit plant research and information center that inspects and certifies every seed lot sold by merchants. Thanks to this registration, the seed lot can be tracked through the whole system. This allows BSPB to double check royalty collection because they receive a declaration from each seed merchant that specifies how many tons of each variety they have sold and the royalty owed (Galushko and Gray, 2013).

5.3.3 The Royalty Collection System

In the UK, the FSS royalty rate and its collection mechanism is different from the certified seed royalty rate. All the royalties on certified seed and FSS are collected through BSPB who retains about ten percent for its society and disperses the rest back to the breeders (Galushko and Gray, 2013). The different royalty rates and money flows are described below and are shown in Figure 5.2.

Farm Saved Seed Royalty Flow:

European and UK law oblige farmers to declare their use of FSS. The FSS collection system relies heavily on the honesty of those declaring their use of protected varieties to the BSPB. Neither the BSPB nor the breeder have right to audit or verify the declaration made by the farmer and therefore have to take it on trust (BSPB, 2011, p. 5).

The UK FSS royalty collection system is the most effective in Europe and generates vital income for plant breeders with generally good cooperation from farmers; however, there are some problems with enforcement. While compliance is generally very high, not all FSS is declared and paid for (BSPB, 2011).

The EU and UK legislation provide three different ways in which FSS royalties can be collected. These are; (1) a contractual relationship between breeder and grower, or (2) an agreement between a breeders association and a farmers association (McKee, pp., 2003) or, if neither of the first two options can be agreed upon, (3) a default royalty rate on FSS of 52.5 percent of the weighted average royalty rate on certified seed grown the year before (Galushko and Gray, 2013).

The British Society of Plant Breeders (BSPB) and the National Farming Union (NFU) negotiated a contractual arrangement and set a uniform royalty rate on FSS, which currently is 52.5 percent of the weighted average royalty rate on certified seed grown one year before (Galushko and Gray, 2013).

About 80 percent of FSS royalties are collected through BSPB mobile seed processors. When seed processors invoice the farmer for seed cleaning and treatment, they also invoice them for the FSS royalty, which is forwarded to BSPB. The processors are paid a small collection fee for this service, which is about 6.7 percent of the total FSS royalties collected.

Certified Seed Royalty Flow:

The collection of certified seed royalty is an easy and transparent system in the UK. NIAB inspects and certifies every seed lot sold by seed growers. This allows BSPB to double check royalty collection because they receive a declaration from each seed grower, which specifies how many tons of each variety they have sold and royalty owed (Galushko and Gray, 2013). BSPB has about 160 sub-licenses with seed growers for production and sales that pay seed royalties to the BSPB. Seed growers are compensated about 1.2 percent on average from the total certified seed royalties collected for their collection efforts.

Figure 5.2 shows the royalty and money (black) flows, information (green) and wheat delivery (orange) flows mentioned above.

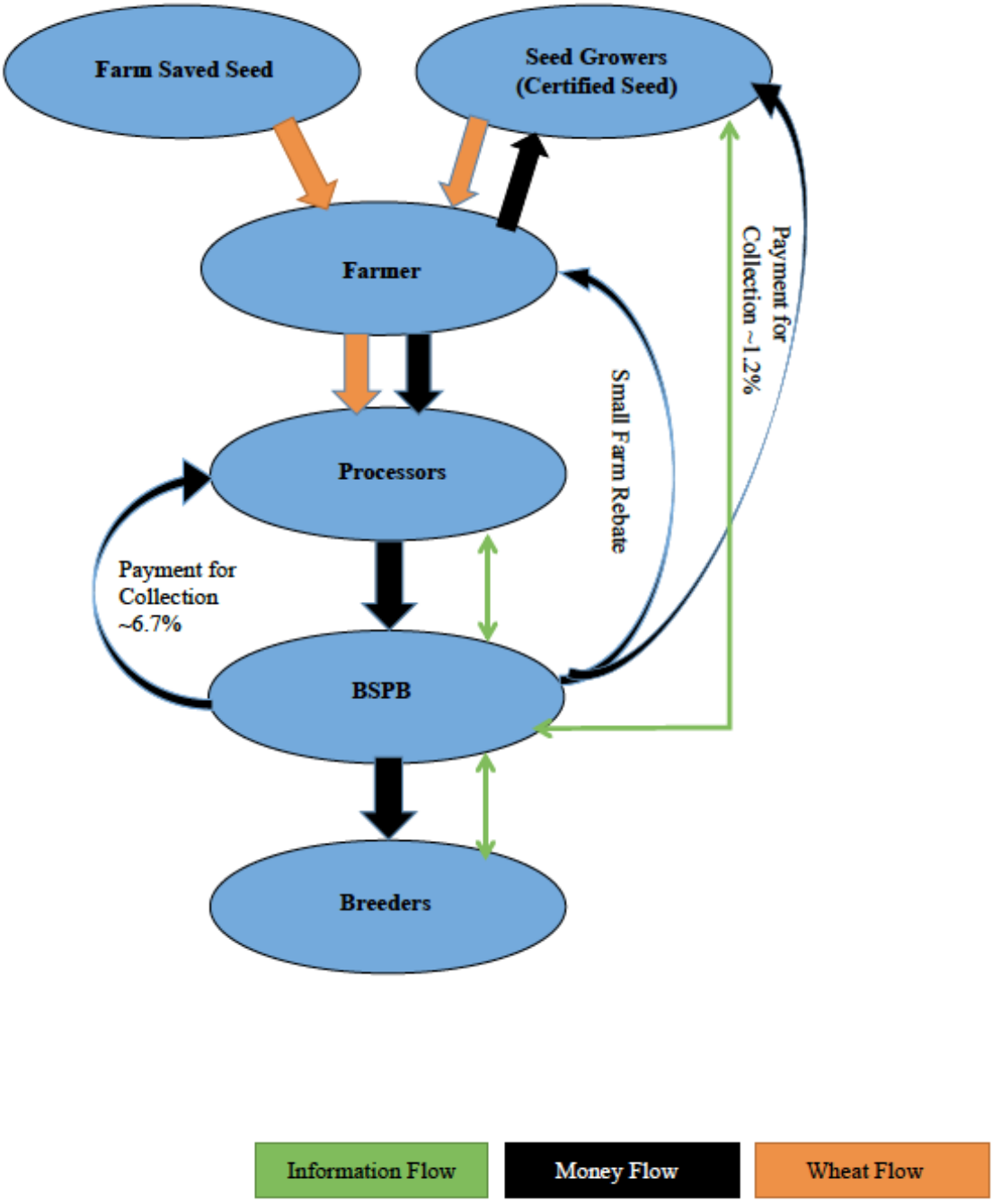

Figure 5.2: Certified and FSS Royalty and Information Flows

Source: BSPB, 2011

5.3.4 Efficiency of the System

The UK royalty collection system operates effectively with little evasion by producers (Galushko and Gray, 2013). Similar to France, the royalty rate of FSS is the same across all varieties eliminating the incentive to mis-declare a variety. Some older varieties, however, are exempt from royalty fees so farmers declaring these varieties submit a grain sample in addition to the royalty exemption claim (Galushko and Gray, 2013).

According to the ISF, the overall ability of breeders to collect royalties on certified seed is 100 percent and approximately 90 percent on FSS. BSPB retains one to two percent of the royalties collected for the costs relating to certified seed collection and about 10 percent for FSS royalty collection costs. About one third of generated royalty income is re-invested into breeding programs. Compliance in wheat is very good at about 90 percent as compared to winter barley (47 percent) or winter beans (49 percent) (BSPB, 2011).

5.3.5 Annual Royalty Revenue

The annual royalty revenue in the UK is quite low, amounting to $28.4 million for the 2010/2011-production year, which is about $1.67 per ton produced. This amount is a very small fraction of the benefits farmers receive from the new varieties. About $9 million is reinvested in to wheat breeding research each year (Galushko and Gray, 2013), the remaining $19.6 million likely accounted for profit. The royalty rate for FSS was £36.10/ton ($60.28/ton)[13] of seed in 2011, which is equivalent to £0.56/ton ($0.94/ton) of harvested grain. This implies that in 2010, the weighted average royalty was set competitively at about £68/ton ($113.56/ton) by the private sector (Galushko and Gray, 2013).

Breeders have very little revenue from royalties to pay shareholders and to invest in breeding (BSPB, 2011). The main issue is the imposition of a ceiling on royalty levels as a component of the seed price. The private sector sees the 52.5 percent royalty for FSS as an element causing underinvestment in the system. It severely constrains what any firm can charge for seed royalty on a new variety. New seed varieties must be conservatively priced in order to capture some market share (Galushko and Gray, 2013, p. 16). About 50 to 65 percent of seed used in the UK is certified seed bought through seed merchants and 35 to 50 percent is FSS. The

[13] The exchange rate for British Pounds to USD was 1 to 1.67 as of April 15, 2014

first collection on FSS royalties in the UK was made in 1996. An increase in FSS use and a lower seeding rate have reduced royalties to the breeders.

5.4 Conceptual Framework

To calculate the average additional yearly benefit created through varietal improvement and its distribution, I am using the average yield increase per year and the world price of wheat. The results are outlined in the following tables including the breeders' benefits, and the transfer of surplus to the farmers due to incomplete property rights.

5.4.1 Analysis: Additional Benefits from Varietal Improvement

The average additional annual benefit achieved from the introduction of a new wheat variety can be calculated, including the share of benefits going to the breeders and to the farmers. Table 5.1 shows the parameters for the UK. Note the parameters are given on a per hectare basis and also per ton of seed, as different reader groups might be interested in different measurement units. These parameters are held constant throughout the calculations presented in the subsequent tables.

The certified seed royalty (row 5) in the UK in 2010 was set at $113.44/ton and the FSS royalty (row 6) is set at 52.5 percent of last year's average certified seed royalty rate. For further explanation on the royalty rates, please refer to subsection 5.3.5.

Table 5.1: Parameters for UK

Parameters for the UK				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
1	Seeding rate (t)		0.1613	1.00
2	Average wheat yield (t)		8.00	49.60
3	Yield gain (t per year)	0.63%	0.05	0.31
4	World wheat price ($)	$ 316.52		
5	Certified seed royalty ($) 2010 avg.		$ 18.30	$ 113.44
6	EPR CVO rate ($/t wheat sold)	52.5% of 5	$ 9.61	$ 59.56

Sources: [1] www.uky.edu/Ag/Wheat/seedrate.html
[2,3] U.N. Food and Agriculture Organization, FAOSTAT, 1961-2010 electronic database at faostat.fao.org, updated 7 August 2012; and U.S. Department of Agriculture, World Agricultural Production 2011-2012 (Washington, DC: January 2013)
[4] International Grains Council (April 15, 2014)
[5,6] Galushko and Gray, 2013

Table 5.2 shows the gross revenue farmers receive from the average additional annual benefit created by introducing a new variety. The additional benefit (row 7) of $15.83/ha or $98.12/ton of seed is calculated by multiplying the average yield gain per year (row 3) with the world wheat price (row 4).

By subtracting the royalty cost to the farmer (rows 8 and 9) from the additional benefit created (row 7), there is the gross revenue for the farmer (row 10). The royalty cost is separated because farmers in the UK use, on average, 42.5 percent of FSS and 57.5 percent of certified seed in their production. The farmer gets $1.22/ha or $7.58/ton of seed from the additional benefit created. This is significantly different compared to France, where farmers get $186.35/ton.

Table 5.2: Revenue for UK Farmers

Additional Annual Revenue for UK Farmers				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
7	Gross Revenue from Innovation ($)	3*4	$ 15.83	$ 98.12
	Cost of Royalty ($)			
8	FSS ($)	42.5% of 6	$ 4.08	$ 25.31
9	Certified Seed ($)	57.5% of 5	$ 10.52	$ 65.23
10	Add. Innovation Revenue for farmers ($)	(7-8-9)	$ 1.22	$ 7.58

Source: author.

Table 5.3 shows the additional revenue for the breeders and the administration costs associated with the introduction of a newly certified seed variety. The gross income for the breeders (row 11) is the royalty revenue of $14.60/ha or $90.54/ton of seed. The cost to the farmer is the benefit to the breeder (rows 8 and 9). The BSPB, however, gets ten percent of the total royalty income as administration cost (row 12) and processors receive 6.7 percent of the FSS royalties (row 13). The remaining additional benefit to the breeders is (row 14) $10.41/ha or $64.53/ton of seed.

Table 5.3: Revenue for UK Breeders and Administration Costs

Additional Annual Revenue for UK Breeders and Administration Costs				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
	Income of Royalty ($)			
8	FSS ($)	42.5% of 6	$ 4.08	$ 25.31
9	Certified Seed ($)	57.5% of 5	$ 10.52	$ 65.23
11	Gross Income for Breeders ($)		$ 14.60	$ 90.54
12	Amount to BSPB ($)	10% (8+9)	$ 1.46	$ 9.05
13	Amount to processors ($)	6.7% of 8	$ 2.74	$ 16.96
14	Total Royalty Revenue for Breeder ($)	(11-12-13)	$ 10.41	$ 64.53

Source: author.

Table 5.4 shows the benefit distribution in percentages. Farmers capture the smallest portion of the benefit, amounting to eight percent (row 15). Breeders capture 66 percent (row 16) and administration costs amount for 27 percent (row 17).

Table 5.4: Benefit Distribution of the Innovation

Benefit Distribution				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
10	% Benefit to Farmer	(10/7)	8%	8%
14	% Benefit to Breeder	(14/7)	66%	66%
12+13	% Administration Cost	(12+13)/07	27%	27%

Source: author.

Interpretation

Farmers receive about eight percent of the additional benefit created by introducing a new wheat variety. Breeders receive 66 percent of the benefit, which is a significantly larger portion.

Figure 5.3 shows the results attained in Table 5.4. The figure illustrates the average additional benefit created in dollars per ton and its distribution amongst farmers and breeders and the portion going to administration due to collection costs.

It takes into consideration the increase in quantity produced per year (94,500 tons), which is calculated by the total tons of wheat production per year times the average yield increase per year times the commodity price of wheat, set at $316.50/ton. Breeders get about $28.4 million in royalties per year in total, which leaves farmers with only eight percent of the benefit.

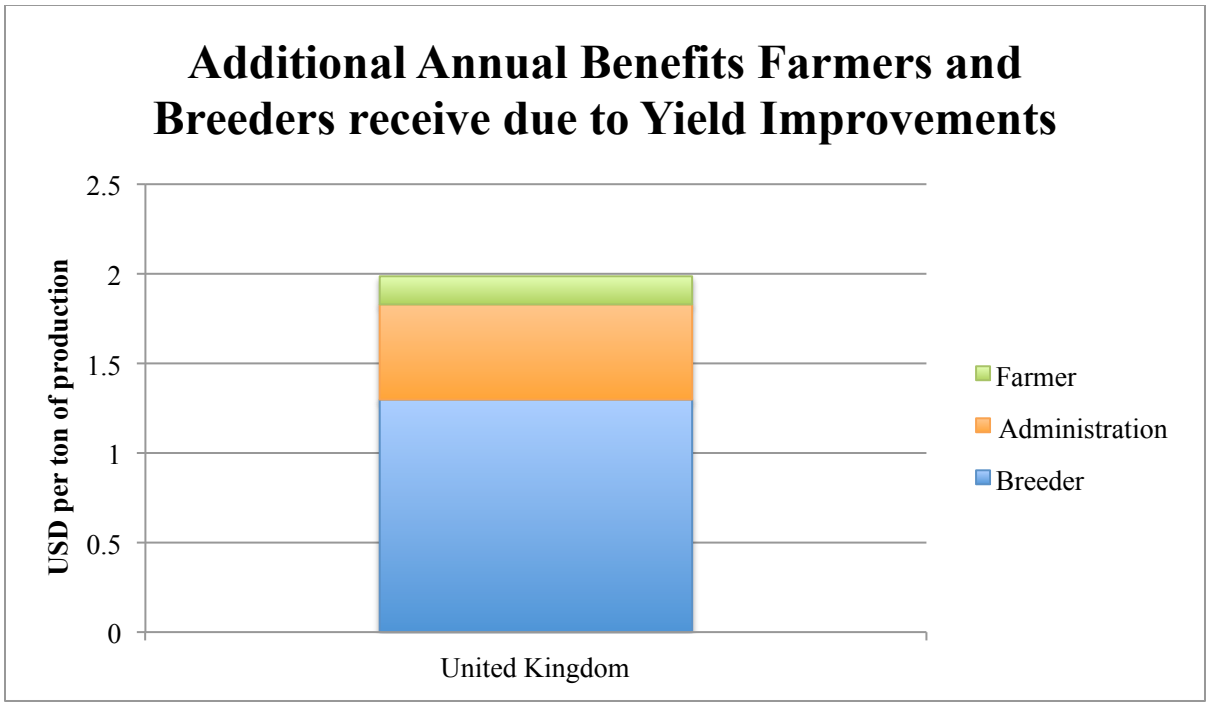

Figure 5.3: Additional Annual Benefits for Farmers and Breeders in the UK

Source: author.

It is important to note that these benefits are an addition to the normal benefits for farmers and breeders. These benefits are created through innovation and are calculated as return over variable cost. Farmers still need to consider additional costs (increased cost of production due to an increased yield, different seed costs, search costs, transportation and storage, riskiness, and agronomic differences) for which they can pay from this additional benefit.

5.5 Graphical Analysis

In the UK, farmers purchase about 35-50 percent FSS and 50-65 percent certified seed. Annual royalty revenues are outlined in subsection 5.3.5 and royalty rates are outlined in Table 5.1.

5.6 Discussion and Conclusion

The UK wheat breeding industry creates only a small increase in benefits per year. Breeders also capture the largest share of benefits. All wheat-breeding companies in the UK are private and reinvest only about a third of the royalty income, which could explain the slow yield gain per year. Farmers are left with eight percent benefit from the royalty. This is significantly lower than what is achieved in France.

6 Australia

Wheat is the second biggest crop grown in Australia. The country produces about 25 million tons of bread wheat and 0.8 million tons of durum wheat annually (Wheat Initiative, 2012). Australia is a consistent supplier of quality and high-protein wheat (Dixon et al., 2009). Other crops grown include barley, sorghum, rapeseed, oats and cottonseed. Figure 6.1 shows the proportion of wheat grown compared to the next five large crops in Australia. It is apparent that wheat and sugar cane have the highest production output in tons.

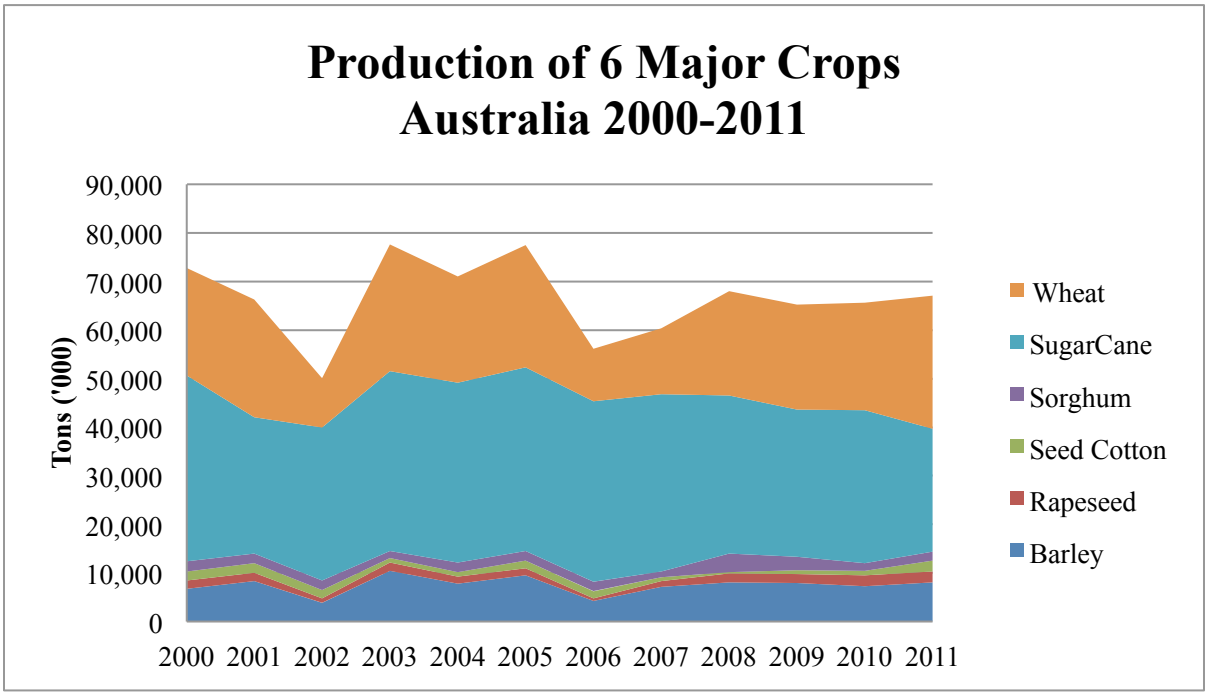

Figure 6.1: Production of 6 Major Crops in Australia

Source: FAOSTAT, 2013.

Public breeding programs such as those carried out by state governments, grower groups, and universities have been replaced by fewer and larger privately owned, or public private partnership (P3) companies (ISF, 2011, p. 11).

The Grains Research and Development Corporation (GRDC) is one of the world's leading grains research organizations, which is responsible to overseeing R&D to deliver improvements in production and profitability in the Australian grains industry (GRDC, 2014). In 1999, the GRDC announced it would discontinue funding wheat breeding. This was when Australia tried to re-focus and re-position their wheat-breeding efforts in a competitive global economy. The

main goal of this initiative was to attract private investment through the end point royalty (EPR) system (AGT, 2014). GRDC created three for-profit private wheat-breeding organizations instead in which it holds a minor share ownership. These companies are Australian Grain Technologies (AGT) Pty Ltd, InterGrain Pty Ltd and HRZ Wheats; which are public-producer-private partnerships (4P) (Alston and Gray, 2013). The major private wheat breeders in Australia are: Australian Grain Technologies, InterGrain, Longreach plant breeders, HRZ Wheats, Bayer CropScience and PacSeeds. All major research organizations involved in wheat research are members of the Australian Winter Cereals Pre-Breeding Alliance (AWCPA) (Wheat Initiative, 2012). Durum is mainly publically bred through the department of Primary Industries and the University of Adelaide.

This section, starts with some background on Australia's wheat-breeding industry and indicate which national and international regulations apply to the royalty structure for farmers and wheat breeders. In section 6.2, I briefly describe the history of Australia's wheat-breeding industry and how it has developed the current royalty collection mechanism described in section 6.3. In addition, I outline the major players involved in variety registration and royalty collection for Australia specifically. In subsection 6.3.2, I explain how Australia collects royalties on certified seed and on farm saved seed (FSS). Finally, in section 6.4, I calculate the average additional annual benefit created through the introduction of new wheat varieties, and the proportion of the benefit going to farmers and breeders from the innovation. A brief summary concludes the section.

6.1 Background

Section 6.1 explains the regulations Australia has adopted to ensure royalty collection on FSS, focusing, in particular, on the legislation provided by the International Union for the Protection of New Varieties of Plants (UPOV). In this section I also explain how the Australian wheat sector is structured, how royalty rates are determined, how the revenue is collected, and ultimately how these plant breeders' rights (PBRs) enable a viable private seed industry.

6.1.1 Intellectual Property Rights (IPRs)

The rights of plant breeders in Australia have been legally protected since 1987. PBRs are aligned with UPOV. UPOV was first established under the Plant Variety Rights Act 1987

(PVRA). PBRs in Australia led to more innovation, as private companies are assured that their investment in research is protected (IP Australia, 2014). To conform with UPOV 91, the Australian Parliament passed new legislation, the Plant Breeder's Rights Act 1994 (IP Australia, 2014).

Australia makes use of the plant breeders' rights (PBR). In 1994, there was a change to Australian implementation of the legislation, which allowed owners to apply an end point royalty (EPR) to grain produced from nominated PBR-protected varieties in order to collect revenue for further research. The duration of protection for wheat is 20 years from the date of issue of the certificate as required by UPOV 91 (GRDC, 2011). In addition to UPOV, Australia is also a member of the Paris Convention for the protection of industrial property, the Patent Co-operation Treaty (PCT) and the Budapest Treaty (Paritypatent, 2013). Australia is also a member of the World Trade Organization (WTO) and must so comply with the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS).

6.2 Historical Development of Wheat Royalty Collection

Over the past 25 years, Australia switched from a predominantly publicly funded and managed system with free wheat varieties to a levy-based system and more recently, to a predominantly royalty-based funding system (Alston and Gray, 2013). This transformation has increased total funding for wheat and has changed the distribution of cost and benefits between farmers, consumers, and the private industry. Australia has undergone three major changes in the past which are: (1) the creation of the Grains Research and Development Corporation (GRDC) and levy-based grain research funding; (2) the PBRs Act and the creation of EPRs; and (3) the development of three for-profit public corporations that undertake wheat-breeding research (Alston and Gray, 2013). In addition to GRDC, there are several federal agencies, state governments and private institutions that fund different aspects of agricultural research (Alston and Gray, 2013).

Since 2010, EPRs allow the wheat-breeding industry to get a high return on investment. Wheat varieties created before 1994 were free of an EPR and breeders introducing new wheat varieties having an EPR had to take this into consideration. The new varieties had to compete with the existing varieties, so new wheat varieties had to show significant benefit to farmers for them to adopt these (Alston and Gray 2013). It took a while for EPRs to generate benefits for

breeders because an enforceable system of levy collection had to be developed. This task included developing new licensing agreements, collection agreements, and educating the industry. To date, Seedvise Pty Ltd. acts as the single agent to negotiate and coordinate the EPR collection system. The PBR system was implemented to enable ongoing investment in plant breeding.

6.3 Current Wheat Royalty Collection System

Australia's royalty collection system is a very transparent and efficient system compared to many other countries. Due to the implementation of an EPR, it is almost impossible for farmers to avoid paying a royalty on FSS or certified seed. In addition to royalties, the wheat breeding industry is also partially funded through levies.

End Point Royalties (EPRs)

In the EPR system, royalties are collected at the point of sale of the harvested product, rather than the seed. EPRs differ from seed royalties in at least four ways: (1) the breeder is able to collect a royalty even if the farmer used FSS or does not buy new genetic material (Perrin and Fuliginiti, 2008); (2) the breeder and farmer share the production risk. Because farmers pay EPRs at the delivery point rather than seed royalties, the better a variety is (i.e. the higher it yields) the higher the royalty payment is because the EPR is linked to the production level; (3) by eliminating a seed royalty (i.e. charging an EPR) the farmer is encouraged to use the best variety and seeding rate. When FSS and certified seed royalties are not the same, farmers might choose to wait a year for a good variety and save the cost of the difference between the certified and the FSS royalty; and (4) breeders can rely on crop marketers to enforce the collection of royalties (Alston and Gray, 2013).

In Australia, EPR rates tend to increase over time. Most royalty rates for wheat are around $1.50/ton (Coles, 2007), however, they are set by the variety owner, considering research and development costs in addition to market forces and the value of the variety to Australian farmers (GRDC, 2011). Today some royalty rates are as high as $3.50/ton.

Figure 6.2 shows how EPRs have evolved since 1994. EPRs have been increasing constantly, even though it took a few years for the new varieties to be adopted, as the older

varieties are exempt from a royalty rate. The EPR for each variety in Figure 6.2 are given in Australian Dollars (AUD).

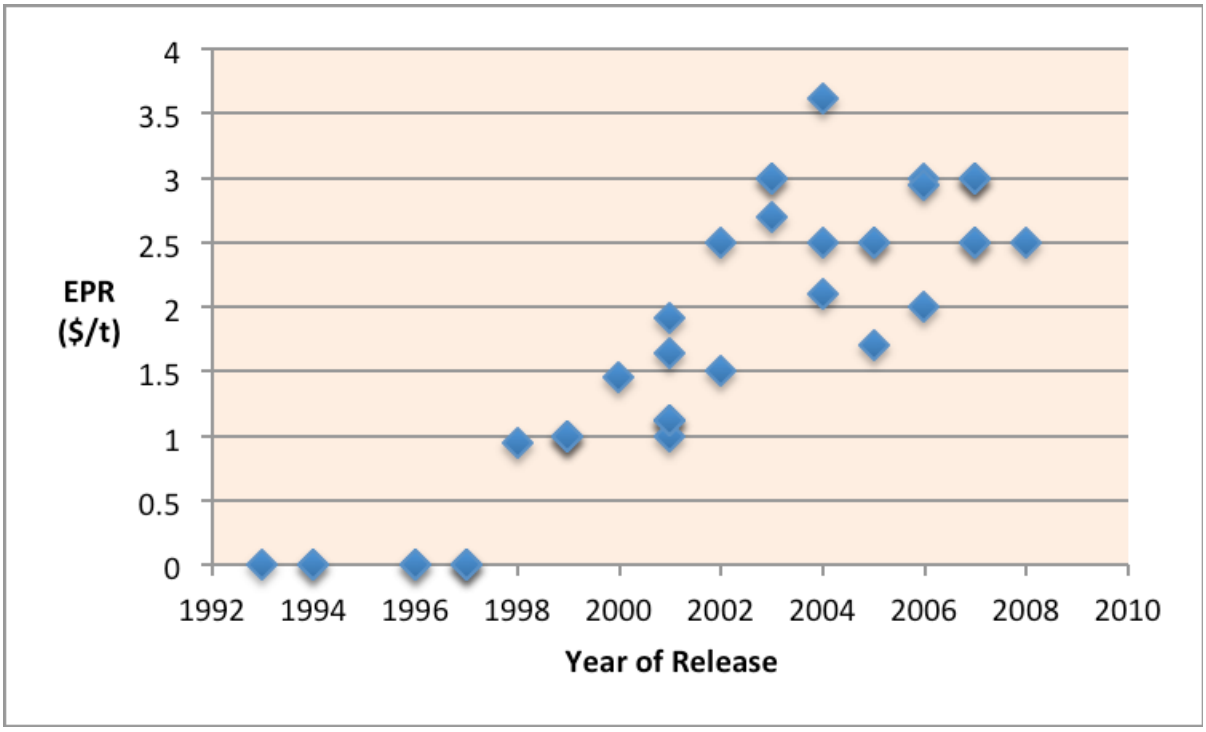

Figure 6.2: Average EPR Rates (AUD/ton) for Wheat Varieties by Year of Release

Source: Alston et al. 2012 p. 29.

The first EPR variety was released into the Australian market in 1996. Today, there are more than 180 EPR varieties in the Australian market (including cereals and pulses) (Variety Central, 2014).

GRDC and Levies

Statutory levy-funded Research and Development Corporations (RDCs) have a profound effect on the Australian agricultural research system. The GRDC is the largest RDC and is funded by a mandatory levy of 1.02 percent on the value of farm sales. The Australian government matches up to 0.5 percent of the farm sale value (GRDC, 2011). Levies predominantly fund agronomy, crop management practices and pre-breeding activities that EPRs do not cover (GRDC, 2011). This levy is collected through the Department of Agriculture, Fisheries and Forestry (Variety Central, 2014). The GRDC manages levies and government

funds (Coles, 2007). The government support helps to compensate for spillover benefits beyond the levy-paying industry and reduces the tendency to set the levies too low (Alston et al. p. vi, 2012).

6.3.1 Institutions Involved in Royalty Collection

Seedvise Pty Ltd is responsible for the EPR deduction and collection. GRDC plays a major role in levy-collection, which is another important funding tool in Australia.

SeedVise Pty Ltd

Seedvise Pty Ltd (Seedvise) has been appointed as EPR agent for a number of royalty managers. Seedvise negotiates and coordinates the EPR collection system (Alston et al. p. 24, 2012) and Grain Trade Australia (GTA) supports this approach. Many major grain buyers in Australia entered contracts with Seedvise and agreed to automatically deduct the required EPR from the farmer's grain payment on behalf of Seedvise. The grain buyers are paid a small collection fee for this service (Grain Trade Australia, 2014).

6.3.2 The Royalty Collection System

Australia differs markedly from other countries in their royalty collection system. The federal and state governments funded plant breeding until 20 years ago (Coles, 2007). As mentioned earlier, Australia uses an EPR system as the primary source of funding for wheat breeding and to establish and enforce intellectual property rights (IPRs). EPRs can be highly effective in providing IPRs and are comparable to that provided by hybrids and patents (Alston et al., 2012).

There are two collection methods used by the companies responsible for the EPR collection, which are known as royalty managers. The variety is declared at the delivery point after harvest. The royalty is either collected directly or breeders are notified of the quantity and variety sold through the grain buying companies (ISF, 2011). Not just grain sold, but harvest material used on farms for feed needs to be declared and paid for as well (GRDC, 2011). Grain traders participating in EPR collection are part of the EPR Steering Committee, which was developed in 2007. Grain traders either deduct the royalty amount from the farmer's grain payment and remit the royalty directly to the variety owner or make reports on grain purchases, which can be used

by the variety owner to invoice the farmers directly. This mechanism allows for a simple and efficient royalty collection mechanism (Variety Central, 2014). These collection methods are described below and shown in Figure 6.3:

Automatic Deduction of EPRs by the Grain Traders Purchasing the Grain Directly from the Farmer:

Most grain traders in Australia automatically deduct EPR from the farmers' payment when the farmers sell their grain. The collection, however, is only possible when farmers declare the variety with supporting documents, since each variety has a different EPR. In this case, the grain trader remits the EPR payments to the royalty manager with a comprehensive report, identifying the grower, variety and quantity of grain purchased (GRDC, 2011).

Royalty Managers Directly Invoice Growers for EPR Payments:

This system is also shown in Figure 6.3 and applies to growers that decide to use their grain on the farm or sell it to companies that do not automatically deduct EPRs from the grain payments. The royalty managers invoice the farmers directly for outstanding EPRs. These farmers are identified via grain purchase data, which was submitted, under agreement from grain traders and from the information submitted by the farmers through the annual harvest declaration form (GRDC, 2011). On this form, farmers declare quantity of seed sown, quantity of harvest grain sold, used on farm, stored, retained for planting and name of company that purchased the grain (GRDC, 2011).

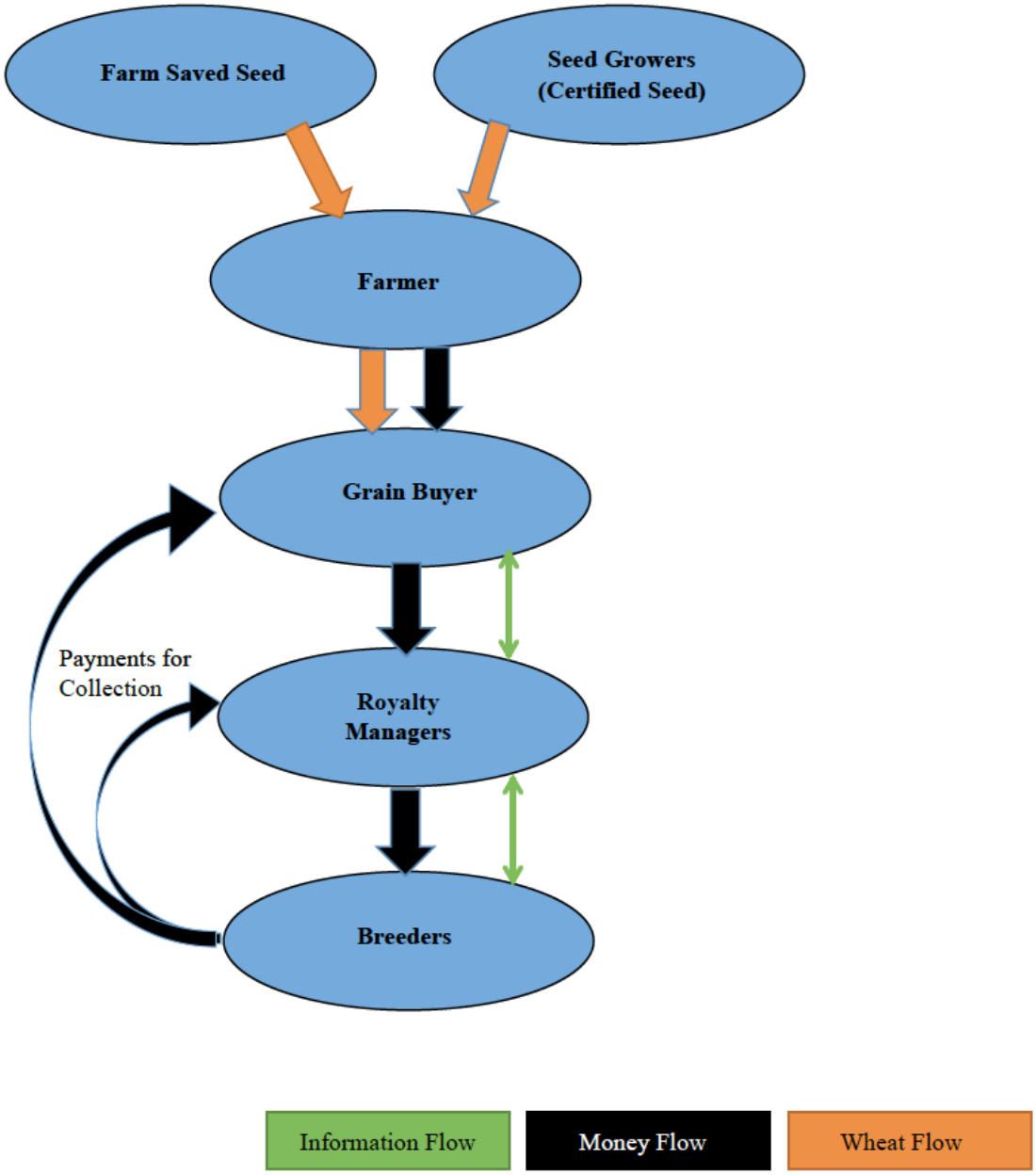

Figure 6.3: Certified and FSS Royalty and Information Flows

Source: GRDC, 2011

6.3.3 Efficiency of Royalty Collection

Farmer compliance with the EPR system is vital for long-term productivity gains and the improvement of varietal quality. Non-compliance can lead to lower returns for plant breeders, resulting in fewer resources for research, less investment and thus results in less competition. Sources used by variety owners to enforce or monitor compliance include:

(1)*Harvest declaration forms*, which are filled out when farmers purchase a variety to which an EPR applies. This is usually completed before seeding.

(2)*Bulk handler reports*, which show sales for a relevant variety. These can be used to invoice farmers if the EPR has not been automatically deducted.

(3) *Grain trader reports* on grain purchases, which can also be used to invoice farmers if EPR was not deducted at point of delivery (Variety Central, 2014).

6.3.4 Annual Royalty Revenue

In 2011, Australia collected royalties on 29.5 million tons of wheat. Assuming the average EPR was AUD 3.00 per ton, this would amount to a total of AUD 90 million in royalty revenue (Alston and Gray, 2013) per year. The use of certified seed in Australia is small with 5 percent, whereas, 95 percent is FSS. Farmers seem to only buy certified seed to change variety (ISF, 2011, p. 11). In addition to the EPR, levies contribute a significant amount to Australia's wheat funding. Levy income averages about $92 (AUD100)[14] million per year plus $46 (AUD50) million from government contributions. Royalties generate a maximum of $9.20 (AUD10) million per year in GRDC revenue (Alston and Gray, 2013).

6.4 Conceptual Framework

To calculate the average additional annual benefit created through varietal improvement and its distribution, I am using the average yield increase per year and the world price of wheat. The results are outlined in the following tables including the breeders' benefits, and the transfer of surplus to the farmers due to incomplete property rights.

6.4.1 Analysis: Additional Benefits from Varietal Improvement

The average additional annual benefit from the introduction of a new wheat variety can be calculated, including the share of the benefits going to the breeders and to the farmers. Table 6.1 shows the parameters for Australia. Note the parameters are given on a per hectare basis but also per ton of seed, as different reader groups might be interested in different measurement units. These parameters are held constant throughout the calculations presented in the subsequent tables.

[14] The exchange rate for AUD to USD used is 1 to 0.93 as of April 15, 2014.

The average royalty for a new variety (row 6) in Australia in 2010 was set at $2.74 per ton of harvest delivered and the FSS royalty (row 5) is an average of $2.51 per ton. For further explanation on the royalty rates, please refer to subsection 6.3.4.

Table 6.1: Parameters for Australia

Parameters for Australia				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
1	Seeding rate (t)		0.1613	1.00
2	Average wheat yield (t)		2.15	13.33
3	Yield gain (t per year)	2.04%	0.04	0.27
4	World wheat price ($)	$ 316.52		
5	EPR CVO rate ($/t wheat sold)	$ 2.51	$ 5.40	$ 33.47
6	Certified seed royalty ($)	$ 2.74	$ 5.90	$ 36.57

Sources: [1] www.uky.edu/Ag/Wheat/seedrate.html
[2] U.N. Food and Agriculture Organization, FAOSTAT, 1961-2010 electronic database at faostat.fao.org, updated 7 August 2012; and U.S. Department of Agriculture, World Agricultural Production 2011-2012 (Washington, DC: January 2013)
[3] Department of Food and Agriculture, http://archive.agric.wa.gov.au/PC_915
[4] International Grains Council (April 15, 2014)
[5,6] Galushko and Gray, 2013

Table 6.2 shows the average gross revenue farmers receive from the additional benefit created by introducing a new variety. The additional annual benefit (row 7) of $13.93/ha or $86.34/ton of seed is calculated by multiplying the yield gain per year (row 3) with the world wheat price (row 4).

By subtracting the royalty cost to the farmer (rows 8 and 9) from the additional annual benefit (row 7), the additional gross revenue for the farmer is shown (row 10). The royalty cost is calculated by regarding the fact that farmers use 95 percent of FSS and five percent of certified seed in their production. The farmer gets a gross return of $5.85/ha or $36.26/ton of seed from the additional benefit created.

Table 6.2: Revenue for Australian Farmers

Additional Annual Revenue for Australian Farmers				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
7	Gross Revenue from Innovation ($)	3*4	$ 13.93	$ 86.34
	Cost of Royalty ($)			
8	FSS ($)	95% of 5	$ 5.13	$ 31.80
9	Certified Seed ($)	5% of 6	$ 2.95	$ 18.28
10	Add. Innovation Revenue for Farmers ($)	(7-8-9)	$ 5.85	$ 36.26

Source: author.

Table 6.3 shows the gross revenue for the breeders and the administration costs associated with the introduction of a new variety. The additional gross income for the breeders (row 11) is the royalty revenue of $8.08/ha or $50.08/ton of seed; therefore, the cost to the farmer is the benefit to the breeder (rows 8 and 9). The estimated amount going to royalty managers for collecting EPRs on behalf of breeding companies (row 12) is deducted from the gross breeder revenue, leaving breeders with an additional annual income of $6.69/ha or $41.45/ton of seed.

Table 6.3: Revenue for Australian Breeders and Administration Costs

Additional Annual Revenue for Australian Breeders and Administration Costs				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
	Income of Royalty ($)			
8	FSS ($)	95% of 5	$ 5.13	$ 31.80
9	Certified Seed ($)	5% of 6	$ 2.95	$ 18.28
11	Gross Income for Breeders ($)	8+9	$ 8.08	$ 50.08
12	Amount to Seedvise ($)		$ 1.39	$ 8.63
13	Total Royalty Revenue for Breeder ($)	(11-12)	$ 6.69	$ 41.45

Source: author.

Table 6.4 shows the benefit distribution in percentages. Farmers capture 42 percent (row 15) and breeders capture 48 percent (row 16). Administration fees account for an estimated 10 percent of the additional benefit created benefit.

Table 6.4: Benefit Distribution of the Innovation

Benefit Distribution				
Number	**Description**	**Calculation**	**Per ha**	**Per t of Seed**
14	% Benefit to Farmer	(10/7)	42%	42%
15	% Benefit to Breeder	(13/7)	48%	48%
16	% Administration Cost	(12/7)	10%	10%

Source: author.

Interpretation

By using the current royalty rates in Australia, breeders receive 45 percent of the additional benefit created and farmers receive 42 percent. Farmers receive a large portion of the additional benefit created through innovation at no cost. Figure 6.4 shows the benefit distribution amongst farmers, breeders, and administration costs. It shows the additional benefit created in dollars per ton. It takes into consideration the increase in quantity produced per year (510,000 tons), which is calculated by the total tons of wheat produced per year times its average yield increase per year; times the commodity price of wheat, set at $316.50/ton. Breeders in Australia charge an average of $2.70 per ton in EPRs, which leaves breeders with a surplus of 48 percent after adjusting for external administrative expenses.

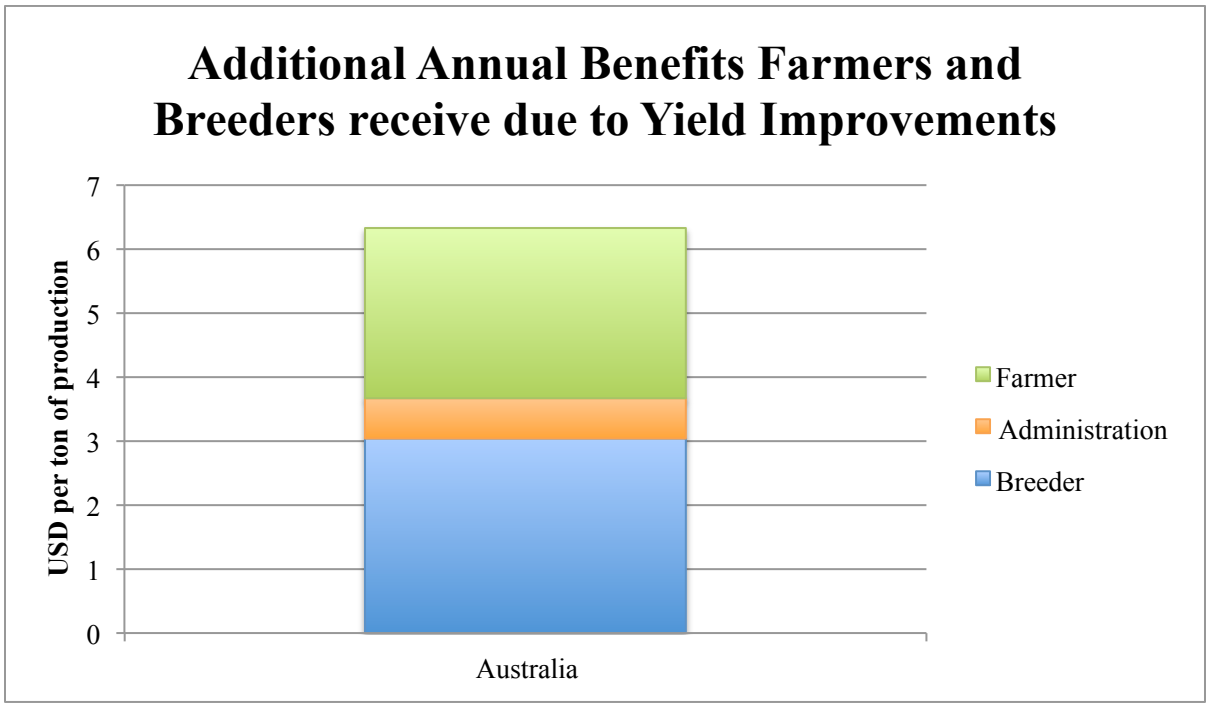

Figure 6.4: Additional Annual Benefits for Farmers and Breeders in Australia

Source: author.

It is important to note that these benefits are in addition to the normal benefits for farmers and breeders. These benefits are created through innovation and are calculated as return over variable cost. Farmers still need to consider additional costs (increased cost of production due to an increased yield, different seed costs, search costs, transportation and storage, riskiness, and agronomic differences) for which they can pay for from this additional benefit.

Benefits for farmers and breeders are about the same, indicating that farmers still receive a large part of the additional benefit at no cost.

6.5 Graphical Analysis

In Australia, farmers use about 95 percent of FSS and purchase about 5 percent of certified seed. The Australian model differs from the United Kingdom (UK) and French model because the royalties on certified and FSS are identical, therefore, the pricing of FSS does not change demand for certified seed. However, pricing of a new variety plays a role in the demand for an older variety. The model for Australia is presented in chapter 3, specifically in subsection 3.4.2.

6.6 Discussion and Conclusion

Australia has significantly increased its research funding through levies and EPRs. Australia's example shows that a country can address underfunding problems through complementary public levy-based, private research funding and a government matching approach. The GRDC creation of the private wheat-breeding industry funded by EPR attracted multinational investment and expertise to Australia. Farmers and breeders receive about the same share of the additional benefit created.

7 Canada

Wheat is a very important crop in western Canada making up the largest seeded acres and largest quantity of crop production, accounting for approximately 60 percent of total grain production. Canada is a major wheat producer on a global scale where production and export of wheat is a multi-billion dollar industry in western Canada (University of Saskatchewan, 2012). Manitoba, Saskatchewan, and Alberta produce 95 percent of Canadian wheat. In these provinces, winters are long and cold and the summers are short and hot with limited rainfall. The low precipitation restricts yields but allows for higher protein content (FAO, 2002).

Canada is one of the largest wheat exporter of wheat and by far, the major exporter of hard durum wheat exporting about 3 million tons per year (48 percent of total world exports). Fluctuations in Canadian production can have an impact on the world supply and price of wheat (FAS, 2004). Annual production of wheat in Canada averages at about 30.6 million tons (Statistics Canada, 2013). Yield increased at a rate of 0.52 percent per year during the period of 1960 to 2007 (Veeman and Gray, 2009), which is considerably lower compared to the United Kingdom (UK), France, and Australia. Canada Western Red Spring (CWRS) accounts for 80 percent of total wheat production, followed by Canada Western Amber Durum (CWAD) (Dakers and Frechette, 1998). Figure 7.1 outlines Canadian wheat production during the period of 2000 to 2011.

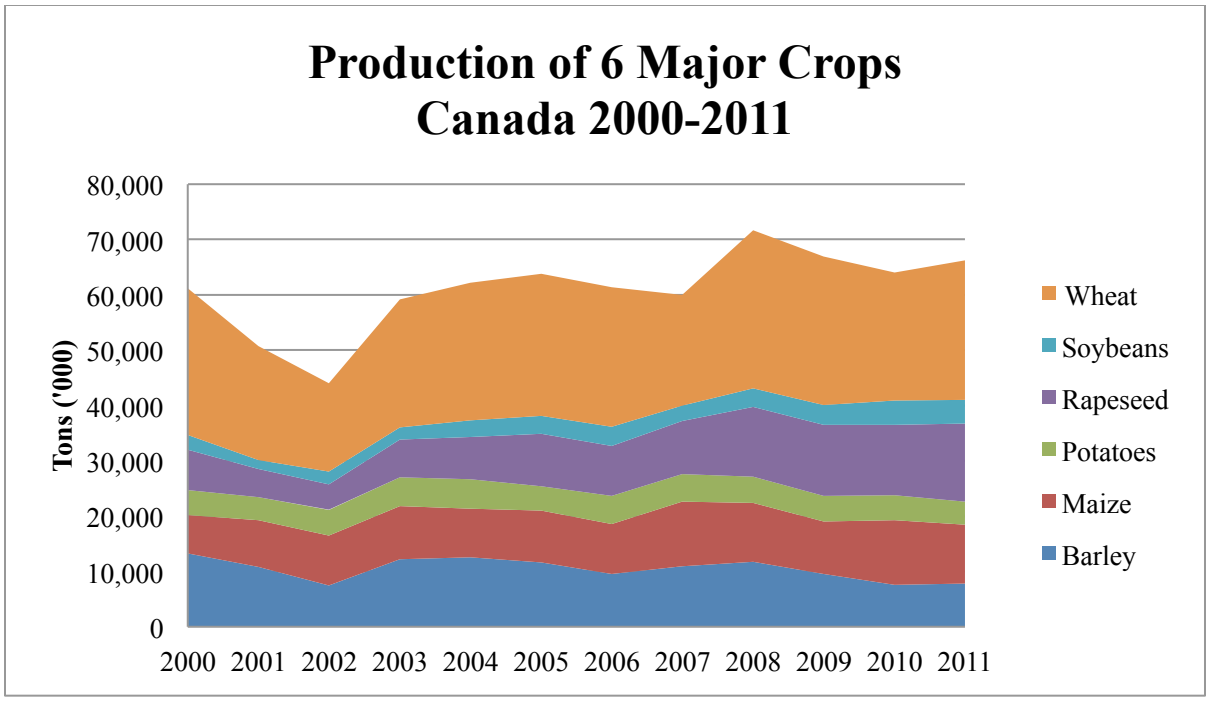

Figure 7.1: Major Crops Grown in Canada

Source: FAOSTAT, 2013

Several public-private partnerships exist between industry and most publically funded research institutions. Breeding is conducted nationally through Agriculture and Agri-Food Canada (AAFC), the largest national wheat researcher and breeder and provincially through universities, mainly through the Crop Development Centre (CDC) at the University of Saskatchewan, University of Alberta, University of Manitoba; the Field Crop Development Centre (FCDC), an Alberta government funded research center and the Western Feed Grain Development cooperative Ltd. (Wheat Initiative, 2013). To date, there is only a couple of private breeding institutions in Canada involved in wheat. Syngenta has had one wheat breeder in Manitoba for many years and has released one wheat variety over the past 30 years. Bayer CropScience entered wheat breeding in 2013 by establishing a wheat-breeding program near Saskatoon, SK.

In this section, I begin with some background on Canada's wheat-breeding industry and indicate which national and international regulations apply to the royalty structure for farmers and wheat breeders. In subsection 7.1.1, I briefly describe the history of Canada's wheat-

breeding industry and how it has developed to the current system described in subsection 7.1.3. In addition, I outline the variety registration procedure for Canada in subsection 7.1.2.

7.1 Background

In section 7.1 I focus on the legislation provided by the International Union for the Protection of New Varieties of Plants (UPOV) in Canada. Intellectual property rights (IPRs) are important so that breeders can collect royalties to cover investment costs and ensure funding for future research. Canada, however, lacks a system of farm saved seed (FSS) royalty collection, simply because IPRs are not strong enough.

7.1.1 Intellectual Property Rights (IPRs)

Canada signed the UPOV 91 convention in 1992; however, the PBR legislation has not been amended to conform with UPOV 91 yet. This is likely to change in the near future as the government of Canada has introduced Bill C-18 to amend the Plants Breeders Right (PBRs) Act to become complaint with UPOV 91. Bill C-18 is expected to pass in the autumn of 2014. In addition to UPOV, Canada is also a member of the World Trade Organization (WTO) and must so comply with the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS). Currently, investment in wheat breeding is scarce because IP in plants cannot be properly protected through TRIPS since Canada does not allow patents in plants.

7.1.2 A Brief Overview of Varietal Registration

To be able to register a variety in Canada, it had to be "visually distinguishable" from other varieties. This requirement was removed in eastern Canada in 1989 and the production of new varieties has since increased (ISF, 2011). In Canada, the variety registration office (VRO) of the Canadian Food Inspection Agency (CFIA) determines whether a new variety can be registered. Only varieties recommended by regional committees are registered (AAFC, 2012). The two regional committees in Canada are (1) the Prairie Grain Development Committee (PGDC) and (2) the Eastern Standards Committee (ESC). Any unregistered variety can only be sold for feed and cannot be sold on export markets.

The variety registration system in Canada is governed by the Seeds Act and managed by the VRO and the CFIA, which has the regulatory authority (Harvey, 2014). The purpose of variety

registration is to (1) ensure the variety meets the international definition of a variety, (2) provides a reference seed sample, and (3) facilitates the National Seed Certification process (CFIA, 2012).

7.1.3 The Canadian Royalty System

In 2011, the Canadian Seed Trade Association (CSTA) estimated national certified seed use at 20 percent (ISF, 2011). Breeders in Canada do not have any legislative power to collect royalties on FSS, which is an issue given the high usage of FSS as compared to certified seed. About 80 percent of seed planted in Canada is FSS (ISF, 2011). Because FSS is free of royalties, farmers have very little incentive to purchase certified seed unless they want to switch varieties. If breeders could collect a royalty on FSS, they would likely be able to increase their funding dramatically and increase their investment in research.

7.1.4 Efficiency of Royalty Collection

Canadian breeders collect a very small amount of royalties on wheat every year, averaging about $7 million per year, mostly on public varieties (CDC, 2014). According to the International Seed Federation (ISF), the Canadian royalty collection system is rated at 20 percent efficiency (ISF, 2011). The term efficiency in the ISF report is used in the following way: 20 percent means that of all wheat that is grown, royalties are collected on only 20 percent of all the sales, which are the sales of certified seed. It assumes collection of FSS royalties with zero percent efficiency (i.e. no farmer pays a royalty) even though there is no legislative power to collect these royalties. Also, efficiency can be interpreted in different ways. The system efficiency is different if looked from the perspective of the breeder or the farmer. The ISF report does not comment on whether the royalties are optimal or too low, nor does it consider if royalties could be collected on FSS. As mentioned, a broader context of efficiency should consider the transfer of surpluses from breeders to farmers due to incomplete property rights from the additional benefits created through varietal improvement.

Figure 7.2 shows the distributions between breeder and farmer from the additional annual benefit created through innovation. As mentioned earlier, Canada has an average production of 30 million tons of wheat per year and has an average yield increase of 0.52 percent (Veeman and Gray, 2009).

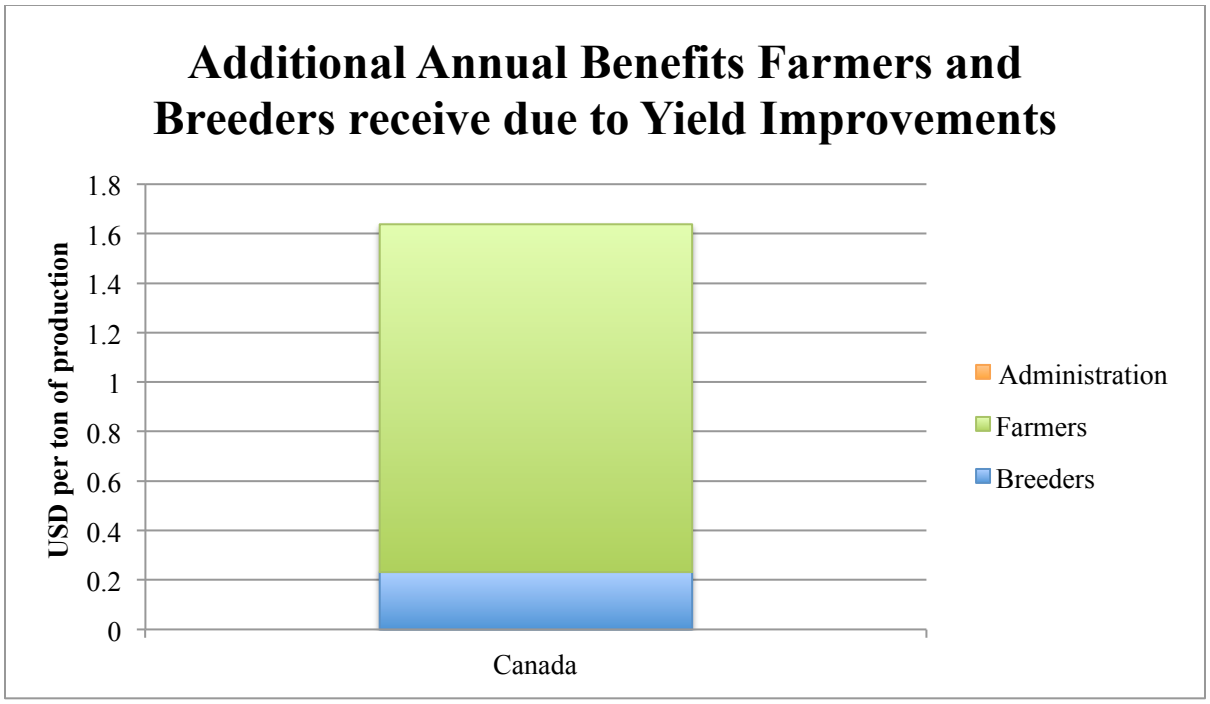

Figure 7.2: Additional Annual Benefits for Farmers and Breeders in Canada

Source: author.

In 2013, wheat production increased 156,000 tons and yielded an additional economic benefit of $49,388,040 given a world price of $316.60/ton. Breeders get an estimated return of $7 million per year, which represents 14 percent of the total benefit. Farmers receive 86 percent respectively.

7.2 Discussion and Conclusion

Because Canada is still part of UPOV 78 and has not yet signed the UPOV 91 convention, there is no legal basis for breeders to implement a system for FSS royalty collection. This means that FSS is freely available to farmers; only 20 percent of production is using certified seed. Breeders can only collect royalties on certified seed and so have very limited revenue and cannot recover their investment costs. As seen in Figure 7.2, breeders capture a very small part of the additional benefit created. This is likely the reason for private underinvestment in wheat research. Canada has the potential to have a viable seed industry if proper legislation is in place to collect royalties on FSS, which can attract more investment, especially from the private sector. More investment in research is likely to lead to better varieties and higher revenue for both, farmers and breeders.

8 Summary and Conclusions

The wheat-breeding systems in France, United Kingdom (UK), Australia and Canada vary significantly. They vary in many ways; implementation of their royalty collection mechanisms, their royalty rates, the number of private and public wheat-breeding firms and, most importantly, the additional annual benefit received by farmers and breeders from innovation. Figure 8.1 shows the different countries and the additional annual benefits for breeders and farmers through the introduction of new wheat varieties. The measure is in $/ton of production. It is important to note, that only royalties invested in wheat breeding are used, not total investment. Publicly funded and levy funded wheat breeding is excluded from this analysis.

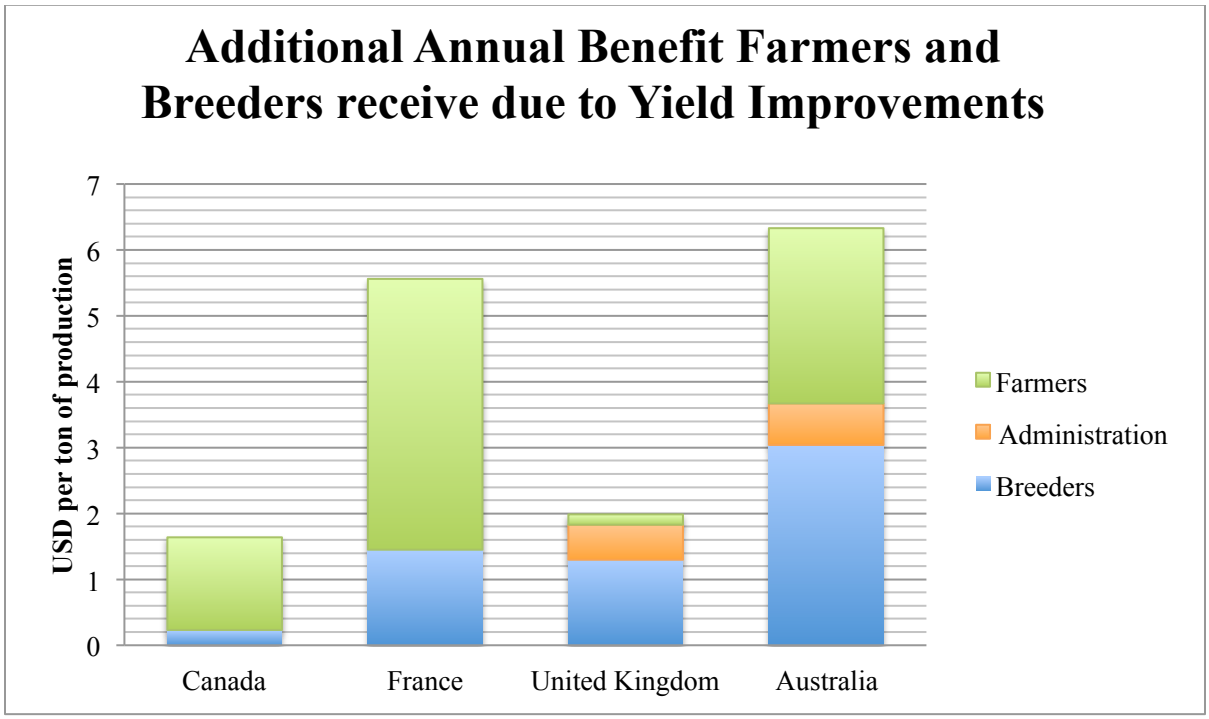

Figure 8.1: Additional Annual Benefits for Farmers and Breeders - Country Comparison
Source: author.

Even though France and UK have similar royalty rates, they vary significantly in the total benefit created. French breeders create an additional annual benefit of approximately $5.71/ton of production, whereas, the UK breeders create an additional annual benefit of about $1.98/ton of production. Breeders in both countries realize roughly the same return per ton of production while farmers in France realize a much greater return in France. There is a clear Pareto-

improvement from the UK system to the French system. In that sense, a shift in systems might be possible. The large difference in additional surplus is possibly due to annual yield gains in the UK are approximately one third of the annual yield gain in France and the different political economies in the two countries. The low yield gain in the UK (Gray and Galushko, 2013) possibly implies that research is less effective or that there is not enough research funding available. In the UK, the private wheat-breeding companies also retain a third of the royalty income as profit for shareholders, which also reduces private research funding. In the UK, there is also a share of the royalty income, which falls away for administrative costs as opposed to France where administration costs are not paid with royalty income. It is possible that France is more successful in innovation as two large cooperatives hold 60-70 percent of the wheat-breeding market share. These cooperatives are owned by farmers and therefore may operate best interest of farmers.

Australia creates the largest amount of additional benefit per year; creating approximately $6.48/ton of production, but farmers do not benefit as much as they do in France. Their plant breeders' rights (PBRs) are implemented in a way that breeders can collect virtually all royalties due through an end point royalty (EPR) system. Australian royalties are smaller than compared to the UK and France; however, they are increasing over time and Australia already has higher total royalty revenue likely due to larger production of wheat. Wheat breeders have a larger amount of funding available for further breeding, however, it is not known if the companies reinvest all their income back to research. Some of the annual income is likely accounted for profit. Breeders in Australia capture a larger amount of the additional benefit created (part which falls away for administrative costs) compared to farmers; and compared to breeders in other countries. From the total royalties collected, about 10 percent falls away for administration costs for royalty collection.

Canadian wheat breeders produce the least additional amount of benefit per year compared to France, UK, and Australia at $1.62/ton. In Canada, administration costs not paid with royalties, rather through other bodies and so is not included in the analysis. Because Canadian wheat breeders currently cannot collect royalties on farm saved seed (FSS), their additional revenue per year is very small and evidently not enough to attract private wheat breeders in Canada. In fact, as mentioned in chapter 7, only two percent of wheat breeding in Canada is

financed by the private sector. If the public wheat breeding programs continue the longer term trend of reducing their investment and no FSS royalties can be collected, the additional annual benefit in Canada has the potential to decrease in the future.

Introducing the Australian system in France would be difficult as long as French farmers have political power. For Canada, both farmers and breeders should be willing to make a move to either the French or the Australian system. Depending on the relative power of the two groups, farmers or breeders determines which system is more likely. The benefits to farmers do not match the gains in yields – as the Australian case shows, while the higher yields generate more additional gross benefits, the farmer share falls. As well, the Australian case also has higher research and development (R&D) costs, meaning not all benefits go back into society as they might go back into research.

According to findings in this thesis, there is a correlation between royalty income and value of yield gain per year. Canada has the lowest royalty income at $7 million and has a yield increase of about half a percent. The UK invests about $9 million per year and has slight yield gain benefit compared to Canada. However, France invests about $54 million and has an average yield increase of 1.8 percent. Australia has a royalty income of about $84 million. The amount reinvested into research is unknown, but Australia has the highest yield gain per year on average, slightly above two percent. The correlation between royalty income and value of yield gain per year could however also be due to many other factors but is consistent with theory. Further research needs to be conducted including public and levy investments in wheat breeding. Including these figures can lead to a different outcome. This study only considers the benefits created in each country given the royalty investment in research and does not consider costs associated with the increased yield gain. These findings lead to the following policy implications:

Policy Implications

The higher the FSS rate, the more breeders can charge for certified seed as shown in the model in chapter 3. This implies that Canada should implement a system to collect FSS royalties and decide on a FSS royalty that allows breeders to charge an adequate royalty for certified seed.

Depending on the objective Canada has for its future wheat-breeding industry (i.e. in favour of wheat breeders or farmers), royalties should be priced accordingly. France has low royalties that are more beneficial to the farmer, whereas, in the UK, royalties are higher and more favourable to breeders.

In addition to royalties, it is important to look at public and private relationships. In France private and public collaborate with each other successfully. If the wheat breeding is left to private firms, it can lead to underinvestment, such as, in the UK or to a decreased benefit to farmers, such as, in Australia.

Implementing UPOV 91 and including the farmers' privilege can balance interests amongst farmers and breeders in addition to public and private groups (Parker, 2014). The new legislation can stimulate investment, enhance access to foreign varieties and facilitate the protection of Canadian varieties abroad, especially since now varieties can be sold beyond the national boundary (Parker, 2014). With the new legislation in place, breeders have the option to take legal action when a breach of contract occurs, license growers and redefine agreements; and most importantly, can create a mechanism to collect royalties on FSS (Parker, 2014).

Benefits for farmers include having access to better varieties, higher diversity in varieties and, aiming towards international harmonization, can attract foreign breeders to Canada (Parker, 2014). In addition, Canada has the opportunity to design and implement a royalty collection system, such as EPRs.

The PBR approach is regarded as the most effective IP system for the protection of new varieties. An optimal and effective IP system needs to balance between protection and access (Dons, 2013). For PBR to be fully effective, all of the world's countries need to be members of UPOV 91 or incorporate all provisions of UPOV 91 in their legislation (Dons, 2013). The updated breeders' rights are needed to provide access to the best genetic resources (Dons, 2013).

8.1 Lessons for Canada

Looking at the history and current situations of France, UK, and Australia, Canada can learn the following lessons:

8.1.1 Lessons from France

- France has a great working system with a mid-sized private wheat-breeding sector that has a long history of partnership.
- France uses a fixed royalty rate, which is set by the industry and farmer unions together. This allows farmers and breeders to plan forward and know the future royalty rates. In addition, this reduces the risk of excessive increases in royalty rates.
- GNIS and SICASOV have a successful working relationship, ensuring a good compliance in royalty collection. Collaboration between farmers' and breeders' unions and government is important in the creation of a royalty mechanism to ensure both parties can benefit from the new legislation.

8.1.2 Lessons from Australia

- EPRs provide a strong protection for new plant varieties, similar to the one provided by hybrids and patents. The EPR system is a mechanism to enforce intellectual property rights (IPRs), which over time can attract private investment for additional wheat breeding and research.
- The Australian breeders generate the most revenue if compared with the France and UK. Private breeders set both certified and FSS royalties.
- During the initial periods of establishing EPRs, the ability to charge a royalty was highly dependent on the availability of royalty free varieties in the market. The private wheat-breeding industry took five years to implement but is profitable and successful today.
- Australia implemented a private wheat-breeding industry successfully using EPRs.
- In Australia, EPRs are variable and tend to increase over time, which can develop as a problem for farmers if firms gain market power and increase royalties dramatically. Currently, royalties are still low compared to France and UK, however they are increasing over time. It is too early to tell if this system will prove to be successful.

8.1.3 Lessons from the UK

- The UK wheat breeding industry is very small, consisting of 6 small private firms. Together they generate very little royalty, even though royalty rates are the highest compared to France and Australia.

- UK stopped public investment in wheat altogether. It is important to note, some public funding can be beneficial because the UK lost many years of research by switching from a completely public to a fully privatized industry. The public scientists stopped breeding after privatization and left the private industry on its own without transitioning period. This implies that if the public withdraws investment, it will not necessarily be replaced by private industry.
- In the UK, there is also a potential of reduction of royalty rates over time, since the FSS royalty rate is a function of the weighted average of the historical certified seed royalty rate.
- The report written by the International Seed Federation (ISF, 2012) rated UK and France as very highly efficient in royalty collection. The results gained in this thesis show, however, that UK is much less efficient in innovation than France.

8.2 Conclusion

UPOV 91, with farmers' privilege, is essential to ensure collection of FSS royalties. With the implementation of UPOV 91, Canada has the legal right to draft a FSS royalty collection mechanism as found in other countries. By implementing UPOV 91, France, UK, and Australia have all increased private and total investment in wheat research and breeding and achieved major research gains. Similar results are expected for Canada. However, all three systems analyzed are still quite new and benefit distributions could change as the systems develop. France started collecting FSS royalties in 1994, whereas, the UK and Australia implemented royalty rate collection in 1996.

Given the current results, a combination of public and private funding, in addition to levies, is likely to be the best result to achieve enough funding for a viable wheat-breeding industry. In France, public and private companies work well together. Future research can be conducted to analyze whether public-private-producer partnerships could lead to better innovation and wheat varieties. A combination of royalties, levy and government matching would likely be an optimum funding mechanism for future wheat breeding. Levies, which were successfully implemented in Australia on wheat, pose a great supplement to royalties and enhance total funding for R&D. Matching government grants to levies in Australia, also successfully increased total funding for wheat breeding and R&D.

9 References

Agriculture and Agri-Food Canada (AAFC). 2012. Market Outlook Report – Wheat Sector Profile Part One: Overview. Accessed March 2, 2013. Online at: http://www.agr.gc.ca/pol/mad-dam/index_e.php?s1=pubs&s2=rmar&s3=php&page=rmar_02_06_2010-11-26.

Agriculture and Agri-Food Canada (AAFC). 2010. Wheat Sector Profile. Part One: Overview (November 2010). AAFC No. 11301E Volume 2 Number 6. Accessed August 3, 2014. Online at: http://www.agr.gc.ca/eng/industry-markets-and-trade/statistics-and-market-information/by-product-sector/crops/crops-market-information-canadian-industry/market-outlook-report/wheat-sector-profile-part-one-overview-november-2010/?id=1378843495280.

Alberta Crop Industry Development Fund (ACIDF). 2014. Accessed September 23, 2014. Online at: http://www.acidf.ca/

Agriculture Development Fund (ADF), 2014. Accessed September 23, 2014. Online at: http://www.agriculture.gov.sk.ca/ADF

Alfranca, Oscar. 2005. Private R&D and Spillovers in European Agriculture. *International Advances in Economic Research* **11:** 201-213

Alston, Julian M., Norton, G.W., and Pardey, P. G. 1995. Science under Scarcity: Principles and practice for agricultural research evaluation and priority setting. Cornell University Press, Ithaca, NY, pp. 513.

Alston, Julian M. 2002. Spillovers. The Australian Journal of Resource Economics. **46:** 315-346.

Alston, Julian M. and Richard S. Gray. 2013. Wheat Research Funding in Australia: The Rise of Public-Private-Producer Partnerships. *Euro Choices Agri-Food and Rural Resource Issues* 12(1): 30-35.

Alston, Julian M., Richard S. Gray and Katarzyna Bolek. 2012. Working Paper. Farmer-Funded R&D: Institutional Innovations for Enhancing Agricultural Research Investments.

Australian Grain Technologies (AGT). 2014. Plant Breeders Rights and End Point Royalties. Accessed April 15, 2014. Online at: http://www.ausgraintech.com/index.php?id=12.

Blakeney, Michael. 2012. Patenting of plant varieties and plant breeding methods. *Journal of Experimental Botany* 63(3): 1069-1074. Accessed March 2, 2013. Online at: http://jxb.oxfordjournals.org.cyber.usask.ca/content/63/3/1069.full.pdf+html.

British Society of Plant Breeders (BSPB). 2011 BSPB Submission to the Hargreaves review. Dr. Penny Maplestone. February 2011.

Canadian Food Inspection Agency (CFIA). 2012. Canada's Variety Registration System. Presentation to Canada Grains Council. Presented by Tony Ritchie. Online at: http://www.canadagrainscouncil.ca/uploads/Tony_Ritchie_CFIA-Canada_s_Variety_Registration_System.pdf.

Canadian Food Inspection Agency (CFIA). 2013. Agricultural Growth Act: Supporting Canada's agriculture industry through effective government. Online at: http://www.inspection.gc.ca/about-the-cfia/newsroom/news-releases/2013-12-09/backgrounder/eng/1386459916162/1386460014131.

Canadian Food Inspection Agency (CFIA). 2014. Variety Registration. List of varieties which are registered in Canada. Wheat. Updated February 2014. Accessed August 3, 2014. Online at: http://www.inspection.gc.ca/english/plaveg/variet/wheblee.shtml.

Chamberlain, Edward. 1933. The Theory of Monopolistic Competition. The Economic Journal. 43(172): 661-666. Published by Wiley on behalf of the Royal Economic Society.

Church, Jeffrey and Roger Ware. **2000.** Industrial Organization- A Strategic Approach. McGraw-Hill Companies Inc.

Coles, Donald J. 2007. Funding Plant Breeding in Australia – A Review of End Point Royalties and Future Funding Requirements. Valley Seeds Pty Ltd. Canadian Seed Trade Association – Summer Meeting July 2007 Accessed June 14, 2013.

Community Plant Variety Office (CPVO). 2013. CPVO statistics on 2013. Available online at: http://www.cpvo.europa.eu/statistiques/CPVO_statistics_summary.pdf.

Consultative Group on International Agricultural Research (CGIAR). 2013. Wheat – Annual Report 2012. Updated on July 11, 2013. Accessed on March 31, 2014. Online at: http://wheat.org/resources/documents-about-wheat.

Correa, Carlos M. 2000. Intellectual Property Rights, the WTO and Developing Countries – The TRIPS Agreement and Policy Options. Zed Books. Accessed February 12, 2013. Online at: http://cnc.sagepub.com.cyber.usask.ca/content/26/1/188.full.pdf.

Crop Development Centre (CDC). 2014. Discussion at CDC at the University of Saskatchewan.

Dakers Sonya and Jean-Denis Frechette. 1998. The Grain Industry in Canada. Parliamentary Research Branch. Accessed March 1, 2013. Online at: http://publications.gc.ca/collections/Collection-R/LoPBdP/BP/prb982-e.htm.

Dasgupta, F. and Stilglitz J. 1980. Industrial Activity and the Nature of Innovative Activity. *Economic Journal* 90: 266-293.

Dixon John, Hans-Joachim Braun, Petr Kosina, and Jonathan Crouch. 2009. Wheat Facts and Futures 2009. International Maize and Wheat Improvement Centre (CIMMYT). Online at: http://repository.cimmyt.org/xmlui/bitstream/handle/10883/1265/91601.pdf?sequence=1.

Dons J.J.M. (Hans). 2013. Intellectual Property Rights Systems and Innovation in the Plant Breeding Industry. *Euro choices – Agri-Food and Rural Resource Issues* 12(1): 36-41.

European Commission, 2010. Evaluation of measures relating to the durum wheat sector within the context of the Common Agricultural Policy: Chapter 3: Overview of the Durum Wheat Sector. Agriculture and Rural Development, November 2010. Accessed, November 12, 2013. Online at: http://ec.europa.eu/agriculture/eval/reports/wheat/index_en.htm.

European Seed Certification Agencies Association (ESCAAM). 2013. France. Accessed February 17, 2013. Online at: http://www.escaa.org/index/action/page/id/6/country/FR.

FAOSTAT, 2011. Food and Agriculture Organization of the United Nations. Commodities by Country (total world). Accessed June 6, 2014. Online at: http://faostat.fao.org/site/342/default.aspx.

FAOSTAT. 2013. Food and Agriculture Organization of the United Nations. Accessed November 12, 2013. Online at: http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor.

Food and Agriculture Organization (FAO). 2002. Bread Wheat – Improvement and Production. FAO Plant Production and Protection Series No. 30. Edited by B. C. Curtis. Accessed March 31, 2014. Online at: http://www.fao.org/docrep/006/y4011e/y4011e00.htm#Contents.

Food and Agriculture Organization (FAO). 2003. World Agriculture: Towards 2015/2030 – An FAO Perspective. Chapter 11 Selected Issues in Agricultural Technology, Accessed March 31, 2014. Online at: ftp://ftp.fao.org/docrep/fao/005/y4252e/y4252e.pdf.

Food and Agriculture Organization (FAO). 2004. Intellectual property rights in plant varieties – International legal regimes and policy options for national governments, Part III: Options available to national governments under existing international IPR agreements protecting plant varieties and Plant Breeders' Rights. Online at: http://www.fao.org/docrep/007/y5714e/y5714e04.htm.

Foreign Agricultural Services (FAS). 2004. Canada Wheat Fact Production Estimates and Crop Assessment Division. USDA. October 19, 2004. Accessed February 12, 2013. Online at: http://www.fas.usda.gov/remote/canada/can_wha.htm.

France Agricole, La. 2007. L'accord interprofessionnel sur le financement de la recherché devrait être renouvelé pour trois ans. Accessed February 17, 2013. Online at: http://www.lafranceagricole.fr/actualite-agricole/ble-tendre-l-accord-interprofessionnel-sur-le-financement-de-la-recherche-devrait-etre-renouvele-pour-trois-ans-5543.html.

Fulton, M.E. 1997. The Economics of Intellectual Property Rights: Discussion. *American Journal of Agricultural Economics* 79(5): 1592-94.

Fulton, Murray and Lynette Keyowski. 1999. The Impact of Technological Innovation on Producer Returns: The Case of Genetically Modified Canola.

Fulton, Murray and Richard Gray. 2007. Toll Goods and Agricultural Policy. Canadian Agricultural Innovation Research Network (CAIRN) Policy Brief. Number 9, October 2007.

Galushko Viktoriya and Richard Gray. 2013. The Privatization of British Wheat Breeding: What can Canada learn? CARIN Publication No. 34. Accessed February 9, 2014. Online at: http://www.ag-innovation.usask.ca/cairn_briefs/publications%20for%20download/final%20UK%20Report%202013.pdf.

Genoplante, 2010. Objectives. Accessed November 12, 2013. Online at: http://www.genoplante.com/content.php?idcontent=objectifs&lg=en.

Government of Saskatchewan. 2014. Varieties of Grain Crops, 2014. Accessed July 8, 2014. Online at: http://www.agriculture.gov.sk.ca/Default.aspx?DN=38162457-1ea6-48cf-8183-0f4e49560fef.

Grain Trade Australia. 2014. Seedvise Pty Ltd – Submission regarding wheat industry End Point Royalty collection fee. Accessed, April 11, 2014. Online at: http://www.graintrade.org.au/sites/default/files/file/ACCC%20re%20Seedvise%20Pty%20Ltd.pdf.

Grains Research & Development Corporation (GRDC). 2011. End Point Royalties (EPR) Fact sheet. September 2011. Accessed April 11, 2014. Online at: http://www.seednet.com.au/documents/End%20Point%20Royalties%20Fact%20Sheet.pdf.

Grains Research & Development Corporation (GRDC). 2014. About us. Accessed August 14, 2014. Online at: http://www.grdc.com.au/About-Us.

Gray, Richard S. and Viktoriya Galushko. 2013. An Overview of Wheat Innovation System in France: A Draft Interim Report. Canadian Triticum Advancement through Genomics (CTAG).

Gray, Richard. 2011. Intellectual Property Rights and the Role of Public and Levy-funded Research: Some Lessons from International Experience, Chapter 13 Improving Agricultural Knowledge and Innovation Systems – OECD Conference Proceedings. Accessed March 2, 2013. Online at: http://agecon.unl.edu/c/document_library/get_file?uuid=1e6d4a65-cd0c-4c89-9ea1-2b059b3e1d0d&groupId=2369805&.pdf.

Grilliches, Z. 1992. The Search for R&D Spillovers. *Scandinavian Journal of Economics* **94**: 29-47.

Harvey, Brian. 2014. Variety Registration Canada, Presentation to Ag-West Bio Information Workshop on Plant Breeders Rights (PBR)-UPOV 91 on April 17, 2014

Helfer, R. Laurence. 2011. Intellectual Property Rights in Plant Varieties: International Legal Regimes and Policy Options for National Governments. Vanderbilt University Law School, Public Law and Legal Theory. For the Development Law Service FAO Legal Office.

Institut National de la Recherche Agronomique (INRA). 2013. Les variétés de blé tender. Accessed November 18, 2013. Online at: http://www7.inra.fr/internet/Directions/DIC/presinra/SAQfiches/bletendre.htm.

International Seed Federation (ISF). 2011. Collection Systems for Royalties in Wheat – An International Study. Accessed March 1, 2013. Online at: http://cdnseed.org/wp-content/uploads/2012/07/OPWCCurtis.pdf.

International Union for the Protection of New Varieties of Plants (UPOV). 2010. Explanatory Notes on Conditions and Limitations Concerning the Breeder's Authorization in Respect of Propagating Material under the UPOV Convention. October 21, 2010. Accessed June 10. 2014. Online at: http://www.upov.int/edocs/expndocs/en/upov_exn_cal.pdf.

International Union for the Protection of New Varieties of Plants (UPOV). 2014. Members of the International Union for the Protection of New Varieties of Plants, International Union for the Protection of New Varieties of Plants, Publication 437, accessed March 20, 2014. Online at: http://www.upov.int/export/sites/upov/about/en/pdf/pub437.pdf.

International Union for the Protection of New Varieties of Plants (UPOV). 2002. General Introduction to the Examination of Distinctness, Uniformity and Stability and the Development of Harmonized Descriptions of New Varieties of Plants. TG/1/3. Accessed March 21, 2014. Online at: http://www.upov.int/en/publications/tg-rom/tg001/tg_1_3.pdf.

International Union for the Protection of New Varieties of Plants (UPOV). 2009. Explanatory Notes on Novelty under the UOPV Convention. UPOV/EXN/NOV/1. Accessed March 21, 2014. Online at: http://www.upov.int/edocs/expndocs/en/upov_exn_nov_1.pdf.

International Union for the Protection of New Varieties of Plants (UPOV). 2005. UPOV Report on the Impact of Plant Variety Protection. Accessed November 12, 2013. Online at: http://www.upov.int/export/sites/upov/about/en/pdf/353_upov_report.pdf.

International Union for the Protection of New Varieties of Plants (UPOV). 2012. Members of the International Union for the Protection of New Varieties of Plants. Accessed November 12, 2013. Online at: http://www.upov.int/export/sites/upov/members/en/pdf/pub423.pdf.

International Union for the Protection of New Varieties of Plants (UPOV). 2013. Article 14 – Scope of the Breeder's Rights, Paragraph (2). Chapter IV – Application for the grant of the breeder's right. UPOV 1991 Convention. Accessed February 26, 2014. Online at: http://www.upov.int/en/publications/conventions/1991/w_up911_.htm#_14.

Interview 1. 2012. Interview conducted with Limagrain in France.

Interview 2. 2012. Interviews conducted with AM, HL, FD in France.

Interview 3. 2012. Interview conducted with CTPS in France.

IP Australia. 2014. History of PBR in Australia. Plant Breeders Rights. Australian Government. IP Australia. Accessed April 15, 2014. Online at: http://www.ipaustralia.gov.au/get-the-right-ip/plant-breeders-rights/about-pbr/history-of-pbr-in-australia/.

Jaffe, Adams B. 1996. Economic Analysis of Spillovers – Implications for the Advanced Technology Program. Brandeis University and National Bureau of Economic Research. Prepared for the Advanced Technology Program. Accessed June 9, 2014. Online at: http://www.atp.nist.gov/eao/gcr708.htm#II.A.

Jolly, Adam. 2012. The Handbook of European Intellectual Property Management: Developing, managing and protecting your company's intellectual property. 3rd edition.

Knight, Stuart, Simon Kightley, Ian Bingham, Steve Hoad, Ben Lang, Haidee Philpott, Ron Stobart, Jane Thomas, Andrew Barnes and Bruce Ball. 2012. Desk study to evaluate contributory causes of the current 'yield plateau' in oilseed rape. Prepared for Defra.

Kuyek, Devlin. 2001. Intellectual Property Rights: Ultimate Control of Agricultural R&D in Asia. GRAIN magazine. Accessed March 2, 2013. Online at: http://www.grain.org/article/entries/30-intellectual-property-rights-ultimate-control-of-agricultural-r-d-in-asia.

Lence, Sergio H., Dermot J. Hayes, Alan McCunn, Stephen Smith, and William S. Niebur. 2005. Welfare Impacts of Intellectual Property Protection in the Seed Industry. *American Journal of Agricultural Economics* 87(4): 951. Accessed March 23, 2013. Online at: http://www.jstor.org.cyber.usask.ca/stable/pdfplus/3697782.pdf?acceptTC=true.

Lence, Sergio H., Dermot J. Hayes. 2008. Welfare Impacts of Cross-Country Spillovers in Agricultural Research. *American Journal of Agricultural Economics* 90(1): 197-215. Accessed June 6, 2014. Online at: http://ajae.oxfordjournals.org/content/90/1/197.abstract.

Lipsey, R. G. and K. Lancaster. 2956-1957. The General Theory of Second Best. *Review of Economic Studies*. 24: 11-32.

Maps of the World. 2014. World Map with Top Ten Countries by Wheat Production. Accessed April 25, 2014. Online at: http://www.mapsofworld.com/world-top-ten/world-map-countries-wheat-production.html.

Math. (??) Comment établir le bon taux de semis dans vos céréales, Accessed November 18, 2013. Online at: http://easterngrains.ca/newWS/download.php?i=BQtgHTW6raWuMlQcM25irKMyVUylVT9vLFOaozueVUSlVTMlraMzVUShLJLtnJWzVUQcMryhrKWzYzAkpj== and http://www.fao.org/wairdocs/x5163f/x5163f02.htm.

McKee, Juno. 2003. The scope for adding value in UK wheat food chains through plant breeding. Nuffield Farmers Fund Scholarship.

Moschini, G., and H.E. Lapan. 1997. Intellectual property rights and the welfare effects of agricultural R&D. *American Journal of Agricultural Economics*. 1229-1242.

NIVAP. 2013. Netherlands Potato Consultative Foundation, Legislation to protect breeders. Accessed January 15, 2013. Online at: http://www.aardappelpagina.nl/explorer/pagina/breedlegis.htm.

Nottenburg, Carol. 2012. Can IP rights protect plants? Patentlens. Accessed March 20, 2013. Online at: http://www.patentlens.net/daisy/patentlens/1234.html.

Ostrom Vincent and Elinor Ostrom. 1999. Public Goods and Public Choices. Workshop in Political Theory and Policy Analysis, Indiana University. Accessed June 6, 2014. Online at: http://socsci.colorado.edu/~mciverj/Ostrom-PG%26PC.PDF.

Paritypatent. 2013. Accessed July 1, 2013. Online at: http://paritypatent.com/plant-europe.php?country_id=56.

Parker, Anthony. 2014. Bill C-18 Proposed UPOV'91 Amendments to Canada's PBR Act. Presentation to Ag-West Bio, Plant Breeders Rights (PBR)-UPOV 91 information workshop on April 17, 2014.

Perrin, R.K. and L.E. Fulginiti. 2008. Pricing and Welfare Impacts of New Crop Traits: The Role of IPRs and Coase's Conjecture Revisited. *AgBioForum* 11(2): 134-144. Online at: http://www.agbioforum.org.

Pray, Carl E. 1996. The impact of privatizing agricultural research in Great Britain: An interims report on PBI and ADAS. *Food Policy* 21(3): 305-318.

PVP Gazette. 1983. Law on the Protection of New Plant Varieties 33: No. 70-489 of June 11, 1970. France. Accessed February 16, 2013. Online at: http://www.upov.org/export/sites/upov/en/publications/npvlaws/france/france.pdf .

Reinganum J. 1989. The Timing of Innovation: Research, Development, and Diffusion. Handbook of Industrial Organization – Chapter 14. R. Schmalensee and R. Willig (eds.). Amsterdam, Netherlands: North-Holland, **1:** 850-908.

Ross, Lester and Libin Zhang. 1999. Agricultural Development and Intellectual Property Protection for Plant Varieties: China Joins the UPOV. 17 UCLA. Basin L.J. 226 (1999-2000) Accessed August 19, 2013. Online at: http://heinonline.org/HOL/Page?handle=hein.journals/uclapblj17&div=13&g_sent=1&collection=journals.

SICASOV. 2013. Accessed January 11, 2013. Online at: http://sicasov.com/info/pages/internet/en/grpActivitesRole.html.

Statistics Canada. 2013. Production of Principal Field Crops, July 2013. Accessed August 14, 2014. Online at: http://www.statcan.gc.ca/daily-quotidien/130821/dq130821a-eng.htm.

University of Saskatchewan. 2012. Winter Cereal Production Marketing. Winter Wheat Production Manual. Chapter 25. Accessed March 1, 2013. Online at: http://www.usask.ca/agriculture/plantsci/winter_cereals/winter-wheat-production-manual/chapter-25.php.

Variety Central. 2014. End Point Royalties, Accessed April 11, 2014. Online at: http://varietycentral.com.au/end-point-royalties.

Veeman Terrence S. and Richard Gray. 2009. The Shifting Patterns of Agricultural Production and Productivity in Canada. The Shifting Patterns of Agricultural Production and Productivity Worldwide – Chapter 6. Accessed February 12, 2013. Choices Magazine Q10, Q16. Online at: http://www.card.iastate.edu/books/shifting_patterns/pdfs/chapter6.pdf.

Wheat Initiative, 2013. Research Organizations – France. Accessed November 12, 2013. Online at: http://www.wheatinitiative.org/research/funding/research-organizations/france.

Wood, Levi. 2013. Wheat Growers support move to modernize seed regulations. Western Canadian Wheat Growers. Letter written on December 9, 2013. Online at: http://wheatgrowers.ca/images/E0334801/Dec_09_13_WGSupportMovetoModernizeSeedRegulations.pdf.

World Trade Organization (WTO). 2014. Members and Observers. Understanding the WTO. Accessed, March 20, 2014. Online at: http://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm.